A GUIDE

TO THE

SCIENTIFIC KNOWLEDGE

OF THINGS FAMILIAR.

WITH AN APPENDIX OF QUESTIONS WITHOUT ANSWERS

BY

THE REV. DR. BREWER,

TRINITY HALL, CAMBRIDGE,

AUTHOR OF "HISTORY OF FRANCE TO THE CURRENT YEAR.
(See a list of other works before the preface.)

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N.B. In the present edition the subject of "latent heat," (pp. 33, 34, and again from pp. 99 to 106,) *has been made conformable to the present advanced knowledge of the subject.*

TO

GEORGE TUDOR, ESQ.,

41, PORTMAN SQUARE, LONDON;

AND

AVENUE MATIGNON, No. 17, FAUBOURG ST. HONORE.

DEAR SIR,

In dedicating to you this Edition of my 'GUIDE TO SCIENCE," I am anxious no less to show how highly I appreciate the encouragement you are accustomed to extend to Science and Literature, than to offer a slight testimony of my gratitude for much personal kindness and attention.

I have the honour to remain,

Dear Sir,

Your humble and faithful servant,

THE AUTHOR.

JANUARY, 1894.

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Preface to the Forty-fifth Edition.

No science is more generally interesting than that which explains the common phenomena of life. We see that salt and snow are both white, a rose red, leaves green, and the violet a deep purple; but how few persons ever ask the reason why! We know that a flute produces a musical sound, and a cracked bell a discordant one—that fire is hot, ice cold, and a candle luminous—that water boils when subjected to heat, and freezes from cold; but when a child looks up into our face and asks us "why?" -how many times is it silenced with a frown, or called very foolish for asking such silly questions!" The object of the present book is to explain above 2000 of these questions (which are often more easily asked than answered) in language so simple that a child may understand it, yet not so foolish as to offend the scientific. In order to secure the strictest accuracy in the answers, the most approved modern authors have been consulted, and each addition has been submitted to the revision of gentlemen of acknowledged reputation for scientific attainments. Sincere thanks are due to the Rev. A. Bath Power, M.A., F.C.S., of Norwich, and to Robert James Mann, M.D., for their very careful revision of the sixth, as well as for much useful information in some of the former editions;* the almost unparalleled success of this little volume, of which 300000 copies have been printed since the year 1848, is an incontrovertible proof of its acceptability. The Author has spared neither labour nor expense to render his "*Guide to the Scientific Knowledge of Things Familiar*," instructive and amusing to the young, as well as to those of maturer life.

To teachers ot schools it may be advisable to state, that, as every question has been again and again submitted to a most rigid investigation, no alteration of the text will be made in future editions; although such as may be needful, to render the oook most generally useful, shall be given by annotations from time to time, as subsequent reprints may be demanded.

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* Mr. Simeon Simons, of Cromer, furnished some useful hints for the second edition: and C. Lloyd, Esq., of Oswestry, Salop, a judicious revision of the fifth edition.

* * *

A remarkable instance came before the Author some time since of the statement made in the early part of this preface. The conversation was about smoke—why it was black and not white, like the fine dust of lime. A little child who was present, asked "Why is the kettle so black with smoke?" Her papa answered "Because it has been on the fire;" "But," (urged the child) "what is the good of its being black?" The gentleman replied, "Silly child—you ask very foolish questions—sit down and hold your tongue." He might have read pp. 206, 207, 208, and answered the child more discreetly.

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PART I.

HEAT.

INTRODUCTION.

Q. *What is* HEAT*?*

A. That which produces the sensation of warmth.

Q. *How is this sensation produced?*

A. Simply by an exchange of temperature with some substance warmer than ourselves.

Q. *What is the "stream of heat" from the warmer to the colder substance called?*

A. CALO'RIC. *Caloric*, therefore, is the *agent*, which produces the *sensation of warmth.*

Q. *What is the principal* SOURCE *of heat?*

A. The Sun.

Q. *What other* SOURCES *of heat are there?*

A. Electricity—Chemical Action—and Mechanical Action.

Q. *What are the principal* EFFECTS *of heat?*

A. Expansion, Liquefaction, Vaporization, and Ignition.

CHAPTER I.

Q. *What is the great natural* SOURCE *of heat?*

A. The Sun.

Q. *Why do* BURNING GLASSES *set fire to substances submitted to their power?*

A. Because, when the rays of the sun pass *through* the burning glass, they are bent *towards one point*, called the "focus;" in consequence of which, the light and heat at *this point* are very greatly increased.

Q. *Do the rays of the sun ever set fire to natural substances,* WITHOUT *the assistance of a burning glass?*

A. No: the rays of the *sun*, even in the *torrid zone*, are never *hot enough* to kindle *natural substances*, unless concentrated by a *burning glass*.

CHAPTER II.

Q. *Name a* SECOND SOURCE *of heat.*

A. ELECTRICITY.

Q. *How is* ELECTRICITY *most commonly seen in* NATURE?

A. As *lightning*.

Q. *What is* LIGHTNING?

A. Lightning is *accumulated electricity* discharged from the *clouds*.

Q. *How many different kinds of lightning are there?*

A. As there are *two* kinds of electricity, so there are *two* kinds of lightning also.

Q. *What are the two kinds of* ELECTRICITY *called?*

A. The Vitreous and Resinous;—sometimes the Positive and Negative.

Q. *What causes the discharge of an* ELECTRIC CLOUD?

A. *One* kind of electricity rushing from a cloud, to unite itself with the other kind, either in another cloud, or in the earth.

Q. *What takes place when the two kinds of electricity* MEET?

A. They *neutralize* each other.

Q. *What is a* THUNDER-STORM?

A. The disturbance caused in the air, when successive discharges of accumulated electricity take place.

Q. *What are the sources of the electricity which accumulates in the clouds?*

A. 1st—*Evaporation* from the earth's surface;

2ndly—The *chemical changes* which take place in the earth's surface, and in the air; and

3rdly—Probably *friction* between currents of air of unequal temperature, passing by each other.

Q. *How* HIGH *are the* LIGHTNING CLOUDS *from the earth?*

A. Sometimes they are elevated 4 or 5 miles; and sometimes actually *touch the earth* with one of their edges: But they are rarely *discharged* in a thunder storm, when more than 700 yards above the surface of the earth.

Q. *How do such objects as trees, steeples, animals, &c., help the discharge of electric clouds?*

A. They reduce the distance between the electric cloud and the earth.

Q. *Why is lightning sometimes* FORKED?

A. Because the flash is divided by certain terrestrial objects which it approaches.

Q. *Why is the flash sometimes* ZIG-ZAG?

A. Because lightning *condenses* the

air in the immediate advance of its path and flies from side to side, in order to pass where there is the *least resistance.*

Q. *When is the flash* STRAIGHT?

A. When the *distance* through which the flash has to pass is *small*, so that the air in advance of its path is not sufficiently *condensed*, to cause it to fly from side to side.

Q. *What is* SHEET LIGHTNING?

A. The light of a flash *reflected* in the clouds, when the flash itself is concealed from view.

Q. *What* OTHER *form does lightning occasionally assume?*

A. It sometimes assumes the *globular* form, and sometimes what is called the *brush* form.

This *brush* discharge is what is called "Castor and Pollux," or "Elmos-fire." Dr. Faraday says, it is a discharge between the air and some conductor.

The cause of *globular* lightning is not known.

Q. *Why does lightning produce a flash when it passes through the* AIR?

A. Because the air, being a *non-conductor*, cannot convey it in an invisible form.

Q. *Does lightning never produce a flash when it passes through a* CONDUCTOR?

A. No: electricity passes through all *conductors* in a quiet and invisible form.

Q. *Why does* LIGHTNING *sometimes* KILL *men and beasts?*

A. Because (when the electric current passes through a man or beast) it produces so *violent an action upon the nerves*, as to destroy life.

Q. WHEN *is a person struck dead by lightning?*

A. Only when his body forms a part of the *lightning's path;* i.e., when the electric fluid, (in its way to the earth) actually passes *through his body*.

Q. *Why are animals sometimes* HURT *by lightning, and not killed?*

A. Because the amount of electric fluid which passes through their bodies, is enough to *injure* them; but not to *destroy life.*

Q. *What is* THUNDER?

A. The noise made by the concussion of the air when it *closes* again, after it has been parted by the lightning flash.

A part of the noise is owing to certain *physical and chemical changes* produced in the air by the electric fluid.

Q. *Why is* THUNDER *sometimes* ONE VAST CRASH?

A. Because the lightning-cloud is *near* the earth, so that all the vibrations of the air (on which sound depends) reach the ear at *the same moment,* and seem like *one vast sound.*

Q. *Why is the* PEAL *sometimes an* IRREGULAR *broken* ROAR?

A. Because the lightning-cloud is a long way off; and as *some* of the vibrations of the air have further to travel than others, they reach the ear at *different times*, and produce a *continuous sound.*

Q. *Which vibrations will be* SOONEST *heard?*

A. Those produced in the *lowest* portions of the air.

Q. *Why will those vibrations be heard* FIRST, *which are made* LAST?

A. Because the flash is almost *instantaneous;* but the sound takes a whole *second of time* to travel 380 yards.

Q. *If a thunder-cloud were* 1900 *yards off, how long would the peal last?*

A. *Five seconds:* we should *first* hear the vibrations produced in those portions of the air *contiguous to the earth;* then those *more remote:* and it would be five seconds before those vibrations reached us, which were made in the immediate vicinity of the cloud.

380 × 5 = 1900.

This illustration supposes the lightning to flash directly from the cloud to the listener.

Q. *Why is* THUNDER *sometimes like a deep* GROWL?

A. Because the storm is *far distant* and the sound of the thunder is indistinct.

Q. *How is the sound of thunder affected by* LOCAL *circumstances?*

A. The *flatter* the country, the more unbroken the peal. *Mountains* serve to *break* the peal, and make it harsh and irregular.

Q. *What is the cause of* ROLLING THUNDER?

A. The echoes of the peal reverberating amongst masses of cloud and terrestrial objects.

Q. *Why is a flash of lightning generally followed by* POURING RAIN?

A. Because it produces a change in the *physical condition* of the air, rendering it unable to hold so much water in solution as it could before; in consequence of which, a part is given off in heavy *rain.*

Q. *Why is a flash of lightning generally followed by a* GUST *of* WIND?

A. Because the *physical condition of*

the air is disturbed by the passage of the lightning, and wind is the result of this disturbance.

Q. *Why is there no thunder to what is called* SUMMER LIGHTNING?

A. Because the lightning-clouds are *so far distant*, that the sound of the thunder is *lost*, before it reaches the ear.

Q. *Do* THUNDER-BOLTS *ever drop from the clouds?*

A. No: the notion of thunder-bolts arises from the *globular* form which lightning sometimes assumes.

Q. *Why is thunder often several moments* AFTER *the* FLASH?

A. Because it has a long way to come. Lightning travels nearly *a million* times faster than thunder; if, therefore, the thunder has *a long way to come*, it will not reach the earth till a considerable time *after the flash*.

Q. *Why can we tell the* DISTANCE *of a thunder cloud, by observing the interval which elapses between the flash and the peal?*

A. Because the flash is *instantaneous;* but thunder will take a whole *second of time* to travel 380 yards; hence, if the flash be five seconds before the thunder, the cloud is 1900 yards off.

The speed of lightning is so great, that it would go 480 times round the earth in one minute; whereas thunder would go scarcely 13 miles in the same space of time.

Q. *What* PLACES *are most dangerous during a* STORM?

A. It is very dangerous to be near a tree, or lofty building; a river, or any running water.

Q. *Why is it* DANGEROUS *to be* NEAR A TREE *or lofty building, during a thunder-storm?*

A. Because a tall object (like a tree or spire) will frequently *discharge* a lightning-cloud; and if any one were standing near, the lightning might diverge from the tree, and pass through the fluids of his body.

Q. *How can a* TREE *or* SPIRE DISCHARGE *a lightning-cloud?*

A. A lightning-cloud (floating over a *plain*) may be *too far off* to be discharged by it; but as a tree or spire would *shorten* this distance, it might no longer be too far off to be discharged.

For example—if a lightning-cloud were 700 yards above a conductor, it would be *too far off* to be discharged;—but a tree or spire 50 yards high, would make the cloud only 650 yards off a conductor; in consequence of which, the cloud might be instantly *discharged.*

Q. *Why would lightning fly from a tree or spire, into a* MAN *standing near?*

A. Because the electric fluid always chooses for its path the *best conductors:* and, if the human fluids proved the better conductor, it would pass through a man standing near the tree, rather than down the tree itself.

There would be no danger if the tree or spire were made of *metal* because metal is a better conductor than the human fluids.

Q. *Does lightning go through the inside, or down the outside of a tree?*

A. It runs down a tree between the bark and the wood, where the sap is most abundant.

Q. *Why does lightning take its course between the bark and wood of a tree?*

A. Because it makes choice of the

best conductors; and this part of a tree is best suited for a conductor.

Q. *Why does lightning pass through the* INSIDE *of a man?*

A. Because the fluids of the human body make a better conductor than the *skin*; therefore, lightning passes through a man, and not down his skin.

Q. *Why is it* DANGEROUS *to be near water during a thunder-storm?*

A. Because water is a good conductor; and lightning always takes in its course the *best conductors.*

Q. *Why is it dangerous for a man to be* NEAR WATER, *in a thunder-storm?*

A. Because the *height of a man* may be sufficient to discharge a cloud: and (if there were no *taller* object nigh) the lightning might make the man its conductor to the water.

See the first note on p. 13

Q. *Why is it dangerous to remain in a* CHURCH-STEEPLE, *during a thunder-storm?*

A. Because the church steeple is a tall object, and composed of imperfect conductors.

Q. *Are iron houses dangerous during a storm?*

A. No. Because the metal walls will convey the electric fluid harmlessly to the ground.

Q. *What* PARTS *of a building should be avoided during a thunder-storm?*

A. Those connected with the roof by a continuous line of conducting substances, but which have no outlet of conductors downwards.

Such as the *stove* with its column of *ascending smoke*.

Q. *Why has the stove no outlet of conductors downwards?*

A. Because it stands upon stone, and is embedded in bricks; both of which are non-conducting substances.

Q. *Would lightning leave the stove and strike a person standing near it?*

A. It might, if by this means a more direct passage were offered to some conducting substances.

Q. *When does lightning pass* FROM THE EARTH *to the* CLOUDS?

A. One kind of electricity always passes *upwards to the clouds*, whenever the *other* kind passes *downwards to the earth.*

Q. *Which kind of electricity passes* DOWNWARDS, *from the clouds to the earth?*

A. Generally the *vitreous*, but occasionally the resinous.

Q. *Which kind of electricity passes* UPWARDS, *from the earth to the clouds?*

A. Generally the *resinous*, but occasionally the vitreous.

Q. *Why is* VITREOUS *electricity so called?*

A. Because it was first procured by rubbing glass.

Vitreous is a Latin word, meaning "of the nature or property of glass."

Q. *Why is* RESINOUS *electricity so called?*

A. Because it was first procured by rubbing resinous substances.

Q. *Are there any other names by which the vitreous and resinous electricities are also known?*

A. They are sometimes called positive and negative electricities.

So called by Dr. Franklin and his disciples.

Q. *Why were the terms "positive" and "negative" employed to express conditions of electricity?*

A. Because the early electricians conceived that there were not two *kinds*, but only two *states* of electricity; the one marked by a superabundance, and the other by a deficiency, of one and the same fluid.

Q. *Why is it dangerous to lean* AGAINST A WALL *during a thunder-storm?*

A. Because the electric fluid will sometimes run down a *wall;* and would leave the *wall* to run down the man, because he is a better conductor.

Q. *Why is it dangerous to* RING *a* BELL *during a thunder-storm?*

A. Because bell-wire is an *excellent conductor;* and the electric fluid, passing down the wire, might run through our hand and injure us.

Q. *Why would the lightning run through a man touching a bell-handle?*

A. Because the human body is a better conductor than the *wall* (between the bell-handle and the floor); and as lightning always chooses the *best* conductor for its path, it would (in this case) pass through the *man*, and injure him.

Q. *Why is it dangerous to* BAR *a* SHUTTER *during a thunder-storm?*

A. Because the iron shutter-bar is an *excellent conductor;* and the electric fluid might run from the bar *through the person touching it*, and injure him.

Q. *Why is it dangerous to be in a* CROWD *during a thunder-storm?*

A. For two reasons: 1st—Because a mass of people forms a larger, and a better conductor, than an individual: and

2ndly—Because the *vapour* arising from a crowd *increases* the conducting power of the air above.

Q. *Why is a* MASS *of bodies a better conductor than a single body?*

A. As *each* living body is a *conductor of electricity*, a connected mass of people would afford a readier passage for a larger quantity of electricity, than a single individual

Q. *Why is danger increased by the* VAPOUR *which rises from a crowd?*

A. Because *vapour* is a conductor, and would lead the electricity down towards the crowd.

Q. *Why is a* THEATRE *dangerous during a thunder-storm?*

A. Because the *crowd*, and *great vapour* arising from so many living bodies, render it an *excellent conductor of lightning.*

Q. *Why is a* FLOCK *of sheep in greater danger than a smaller number?*

A. 1st—Because *each* sheep is a *conductor* of lightning, and the conducting power of the *flock* is increased by its *numbers:* and

2ndly—The *vapour* arising from a flock of sheep *increases the conducting power* of the air above.

Q. *Why is a* HERD *of cattle in danger during a storm?*

A. 1st—Because the *number* of living bodies increases the conducting power of their *animal fluids:* and

2ndly—The vapour arising from a herd increases its conducting power.

Q. *If a person be abroad in a thunder-storm, what place is the safest?*

A. Any place about 20 or 30 feet from some tall tree or building; if it be not near to running water.

Q. *Why would it be safe to stand 20 or 30 feet from some tall tree, in a thunder-storm?*

A. Because the lightning would always choose the *tall tree* as a conductor; and we should not be sufficiently *near* the tree, for the lightning to diverge from it to *us*.

Q. *If a person be in a* CARRIAGE *in a thunder-storm, in what way can he travel most* SAFELY?

A. He should not lean *against* the carriage; but sit upright without touching any of the four sides.

Q. *Why should not a person lean* AGAINST *the carriage in a storm?*

A. Because the electric fluid might run down the sides of the carriage; and (if a person were leaning against them) would make choice of him for a conductor, and perhaps destroy life.

Q. *Why is the* MIDDLE *of a room more safe than any other part of it, in a thunder-storm?*

A. Because the lightning (if it struck the room at all) would come down the chimney or walls of the room; and therefore, the further distant from these the better.

Q. *Why is a* MATTRESS, BED, *or* HEARTH-RUG *a security, to a certain extent, against injury from lightning?*

A. Because they are all non-conductors; and, as lightning always makes choice of the best conductors, it would not choose for its path such things as these.

Q. *Is an* IRON BEDSTEAD *dangerous in a storm?*

A. No; for it is so good a conductor that the electricity would pass down it in preference to the animal fluids.

Q. *Is a man in* METAL ARMOUR *in danger from lightning?*

A. No; for the armour is so good a conductor that the electricity would pass along it in preference to the fluids of the human body.

Q. *Why do* PIECES OF METAL, *such as keys, watches, rings and brooches, carried about the person, increase the danger from lightning?*

A. Because they offer strong inducement to the electricity to *take them in its path*, but do not extend far enough to *conduct it to the earth.*

Q. *Is it better to be wet or dry during a storm?*

A. To be *wet:* if a person be in any open field, the best thing he can do, is to stand about 20 feet from some tree, and get *completely drenched to the skin.*

Q. *Why is it better to be* WET *than dry in a storm?*

A. Because *wet clothes* will conduct the discharge harmlessly over the *surface of the body.*

Dr. Franklin found that he could not destroy a *wet* rat by electricity artificially accumulated, although he could a *dry* one.

Q. *What should a* FEARFUL *person do, in order to be most* SECURE *in a storm?*

A. Draw his bedstead into the middle of his room, commit himself to the care of God, and go to bed; remembering that our Lord has said, "The very hairs of your head are all numbered."

N. B. No great danger needs really to be apprehended from lightning, if you avoid taking your position near tall trees, spires, or other elevated objects.

Q. *What is a* LIGHTNING-CONDUCTOR*?*

A. A metal rod fixed in the earth, running up the whole height of a building, and rising in a point above it.

The point of a conductor should rise well into the air, and be made triangular, like a bayonet.

Q. *What metal is the best for this purpose?*

A. Copper.

Q. *Why is* COPPER *better than iron?*

A. 1st—Because it is a better conductor than iron, and therefore not so easily fused by lightning: and

2ndly—It is not so much injured by weather.

N. B. Electricity does not produce heat when it passes through a good conductor; heat only appears when the free passage of the electric matter is obstructed.

The following numbers express the relative value of several kinds of metal, in conducting electricity:

Lead 1.—Iron 2⅖.—Zinc 4.—Copper 12. Copper is, therefore, 5 times better as a conductor of lightning than iron.

Q. *What is the use of a lightning-conductor?*

A. It furnishes a path for the passage of lightning, which will run down a metal rod rather than the walls of a building, because metal is a better conductor.

Q. *How* FAR *does the beneficial influence of a lightning-conductor extend?*

A. This has not been accurately determined; but one conductor will sufficiently protect a building of ordinary extent.

Q. *Why are not lightning-conductors more generally used?*

A. Because many accidents have arisen from conductors of defective construction.

Q. *How can lightning-conductors be productive of* HARM?

A. If the rod be *broken* by weather or accident, the electric fluid (being obstructed in its path) may damage the building.

Q. *If the rod be unbroken, is any evil to be apprehended from it?*

A. Not if the rod be thick enough to conduct the *whole* current to the earth: But if too small for this purpose, the lightning will *fuse* the metal, and injure the building.

If copper be employed, the diameter of the rod should be half an inch. An iron rod should be somewhat thicker.

Q. *How does* LIGHTNING *sometimes* KNOCK DOWN *houses and churches?*

A. The steeple, or chimney is first struck; the lightning then darts to the iron bars and cramps, employed in the building; and (as it darts from bar to bar) shatters the bricks and stones, which oppose its progress.

Q. *Tell me how St. Bride's Church (London) was nearly destroyed by lightning, about* 100 *years ago.*

A. The lightning first struck the metal vane of the steeple, and ran down the rod; it then darted to the iron cramps, employed to support the building; and (as it flew from bar to bar) smashed the stones which lay between.

Q. *Why did the lightning fly about from place to place, and not pass down in a straight course?*

A. Because it always takes in its course the *best conductors;* and will fly both right and left, in order to reach them.

Q. *Why does* LIGHTNING *turn milk* SOUR?

A. Because it produces a disturbance in the *electrical condition* of milk which causes the complex *organic body* to decompose, and consequently to *turn sour.*

Q. *Is* NITRIC ACID *ever formed in the air by lightning?*

A. Yes. The chemist, Liebig, found nitric acid in 17 specimens of rain-water, *collected* immediately after *thunder-storms:* although in 58 specimens, collected at *other times*, no traces could be found.

Q. *What is nitric acid?*

A. The gases, nitrogen and oxygen, chemically united together, in the proportions of one part of the former to five parts of the latter. ($N O_5$)

Q. *Where do the oxygen and nitrogen come from, that are formed into nitric acid by lightning?*

A. The air itself is composed of oxygen and nitrogen *mechanically* mingled together. The passing lightning has the power of making a portion of these combine *chemically.*

Q. *What is the difference between chemical union and mechanical admixture?*

A. In a *chemical* union, the properties of the mingled bodies are altered. In a *mechanical* admixture, they are not.

Different coloured sands shaken together in a bottle mix mechanically. Water poured on quick-lime unites with it chemically.

Q. *Why does* LIGHTNING *turn* BEER SOUR, *although contained in a close cask?*

A. Because, if beer be *new* and the process of fermentation incomplete, lightning so *accelerates* the process, as to turn the sugar into *acetic acid* before it has passed through the intermediate state of *al'cohol.*

Q. *Why is not* OLD BEER *and* STRONG PORTER *made* SOUR *by lightning?*

A. Because the *fermentation is more complete;* and, therefore, is less affected by electrical influence.

Q. *Why is* METAL *sometimes* FUSED *by lightning?*

A. Because the surface of the metal is *too small* to afford a path for the electric current.

Q. *Why does* LIGHTNING PURIFY *the* AIR?

A. For two reasons: 1st—Because

the electric fluid produces nitric acid in its passage through the air; and

2ndly—Because the agitation of the storm *stirs up the air.*

The "nitric acid" is produced by the *combination* of some portions of the oxygen and nitrogen of the air.*

Q. *How does the production of nitric acid* PURIFY *the air?*

A. Nitric acid acts very powerfully in *destroying the exhalations*, which arise from putrid vegetable and animal matters.

Q. *Why is* LIGHTNING *more common in* SUMMER *and* AUTUMN, *than in spring and winter?*

A. Because the heat of summer and autumn produces *great evaporation*; and the conversion of *water into vapour* always developes *electricity.*

Q. *Why does a* THUNDER-STORM *generally follow very dry weather?*

A. Because *dry air* (being a non-conductor) will not relieve the clouds of their electricity; so the fluid accumulates, till the clouds are discharged in a storm.

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* The oxygen and nitrogen are not *combined*, but simply *mixed* in the ordinary air; but lightning causes some portions of the mixed elements to *combine.*

Q. *Why does a* THUNDER-STORM *rarely succeed wet weather?*

A. Because moist air or falling rain (being a conductor) carries down the electric fluid gradually and silently to the earth.

Q. *Why is* ELECTRICITY *excited by* FRICTION?

A. Because friction disturbs the equilibrium of the two fluids; which remain no longer quiescent, but separate from each other.

When this disturbance takes place, the two fluids are said to be in "a free state."

Q. *Why is a* TREE *sometimes scorched by lightning, as if it had been set on fire?*

A. Because it obstructed the course of the electric fluid, in its way to the earth; and when electricity is obstructed in its path, it gives out great heat.

This would be especially the case in old knarled oaks, and dry sapless trunks, which would be but very imperfect conductors.

Q. *Why is the* BARK *of a* TREE *often ripped quite off by a flash of lightning?*

A. Because some obstruction is offered to the electric fluid in its passage down the tree, and the bark is ripped off by the mechanical violence of the resisted flash.

Q. *Why are* BOUGHS *of* TREES *broken off by lightning?*

A. Because the *mechanical force* of lightning is very great; and, as the boughs of a tree are imperfect conductors, they will often be broken off by this force.

Q. *Why is an electric shock felt* MOST *at the* ELBOW-JOINT?

A. Because the path of the fluid is *obstructed by the joint:* The shock (felt at the elbow) is caused by the fluid *leaping from one bone to another.*

Q. *Is electricity accompanied with any* ODOUR?

A. Yes; near a large electrical machine in good action, there is always a peculiar odour, resembling *sulphur* and *phosphorus;* this odour is called "OZONE."

Pronounce O-ZONE, in two syllables.

Q. *Has this peculiar odour, called* "OZONE," *been observed in thunder-storms?*

A. Yes; at times the *sulphurous* odour prevails, and sometimes the *phosphoric.*

If the gaseous body disengaged by lightning, reaches us in a *concentrated form*, the odour is SULPHUROUS; if in a *diluted* form, it is PHOSPHORIC.

Q. *What are* FUL'GURITES?

A. Hollow tubes produced in sandy soils by the action of lightning.

Q. *How does lightning produce fulgurites?*

A. When it enters the earth, it fuses the flinty matter of the soil into a vitreous (or glassy) substance, called a fulgurite.

Q. *How does lightning sometimes affect the character of* IRON *and* STEEL?

A. Bars of iron and steel are sometimes rendered *magnetic* by lightning.

Q *Give an instance of the magnetic effects of lightning.*

A. Sometimes it will *reverse* the magnetic needles of the electric telegraph, and sometimes *destroy* their magnetism altogether.

Q. *What is meant by the magnetic needles being* REVERSED?

A. That part of the needle which ought to point towards the *north*, is made to point towards the *south;* and that part which ought to point *south*, is made to point towards the *north.*

Q. *How does lightning act upon the magnetic needles of the electric telegraph?*

A. The electric fluid is conveyed along the *conducting* wires round the telegraphic needles.

CHAPTER III.

Q. *What is the third source of heat?*

A. CHEMICAL ACTION.

Q. *What is meant by chemical action being the source of heat?*

A. Many things, when their chemical constitution is changed, (either by the abstraction of some of their gases, or by the combination of others not before united) evolve *heat*, while the change is going on.

Q. *Explain by illustration what you mean.*

A. Water is cold and sulphuric acid is cold; but if these two *cold* liquids be mixed together, they will produce *great heat.*

Q. *Why does* COLD WATER, *poured on* LIME, *produce great heat?*

A. Because the water *unites* with the lime; and becoming *solid*, gives off that heat, which was necessary to retain it in a fluid state.

N. B.—Heat is always *evolved*, when a fluid is converted into a *solid* form. Heat is always *absorbed*, when a solid is changed into a *liquid* state.

Q. *Where does the heat come from?*

A. It was in the water before; but was in a *latent state.*

Q. *Was there heat in the cold water and lime, before they were mixed together?*

A. Yes. *All* bodies contain heat; the coldest ice, as well as the hottest fire.

Q. *Is there* HEAT *even in* ICE?

A. Yes; but it is *latent* (i.e. not perceptible to our senses).

Latent, from the Latin word, *Lateo* (to lie hid).

Q. *How do you* KNOW *there is heat, if you cannot* PERCEIVE *it?*

A. Thus: if a pound of ice, 32 degrees of temperature, be melted over a fire, although 140 degrees of heat are absorbed by the process, yet the *temperature* is not increased in the slightest degree.

The melted ice will still be 32° and not 172°.

Q. *What becomes of the* 140° *of heat which went into the ice to melt it?*

A. It is employed in the mechanical work of changing the solid ice into water.

Q. *When water is converted into* STEAM, *how much heat becomes latent or insensible?*

A. As much as 1000 degrees, all of which is employed in the mechanical work of breaking up the water into steam.

Q. *How is it possible for* 140 *degrees of heat to pass into ice without raising the temperature?*

A. Heat, like any other force, can do only one thing at a time. In ice it employs its *whole* force in breaking up the solid into a liquid; and if its whole force is thus employed, it has none left for raising temperature.

Q. *Explain how* 1000 *degrees of heat pass into boiling water without increasing its temperature.*

A. Its *whole* force is employed in changing the water into steam, and if its whole force is so employed, there is none left for raising temperature.

Q. *How can we be made to* FEEL *the heat of* ICE *or* SNOW?

A. Into a pint of snow put half as much *salt;* then plunge your hands into the liquid; and it will feel so intensely cold, that the snow itself will seem *warm* in comparison to it (*see p.* 377).

Q. *Is* SALT *and* SNOW *really* COLDER *than snow?*

A. Yes, many degrees; and by dipping your hands into the mixture *first,* and into snow *afterwards,* the snow will seem to be comparatively warm.

Q. *What is* FIRE?

A. Heat and light, produced by the combustion of inflammable substances.

Q. *How is* HEAT *evolved by combustion?*

A. By *chemical action.* As latent heat is liberated, when water is poured upon lime, by chemical action; so latent heat is liberated in *combustion,* by chemical action also.

Q. *What* CHEMICAL ACTION *takes place in combustion?*

A. The *elements of the fuel* separate from each other, and combine with the *oxygen of the air.*

Q. *What are the* ELEMENTS *of* FUEL?

A. Carbon, hydrogen, and oxygen, together with certain mineral substances found in the ashes.

Q. *What are the* ELEMENTS *of atmospheric* AIR?

A. Oxygen and nitrogen, *mixed* together in the following proportions:—Four gallons of nitrogen and one of oxygen will make 5 gallons of common air.

Air contains small quantities of carbonic acid gas and ammonia, as also vapour of water.

Q. *What is* CARBON?

A. The solid part of fuel. Carbon abounds in all animal bodies; earths, and in some minerals.

Q. *Mention some different species of* CARBON.

A. Common charcoal, lamp-black, coke, and the diamond.

Q. *What is* HYDROGEN?

A. An inflammable gas. The gas used in our streets is hydrogen *driven out of coals by heat.*

Coal gas (more correctly speaking) is carburetted hydrogen, i.e. carbon and hydrogen. *See p.* 293.

Q. *What are the characteristics of hydrogen gas?*

A. 1st—It is the *lightest* of all known substances:

2ndly—It will burn immediately it is ignited: and

3rdly—A lighted candle (immersed in it) will be instantly extinguished.*

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* Hydrogen gas may be made thus:—Put some pieces of zinc or iron filings into a glass; pour over them a little sulphuric acid (vitriol), diluted with twice the quantity of water; then cover the glass over for a few minutes, and hydrogen gas will be given off.

EXPERIMENTS.

If a flame be put into the glass, an EXPLOSION will be made

If the experiment be tried in a phial, which has a piece of tobacco-pipe run through the cork, and a light held for a few moments to the top of the pipe, FLAME will be made.

If a balloon be held over the phial, (so that the gas can inflate it,) the balloon will ascend in a very few minutes.

Q. *What is* OXYGEN?

A. A gas, much heavier than hydrogen; it gives brilliancy to flame, and is essential to animal life.*

Q. *What is* NITROGEN?

A. An invisible gas, which is the principal ingredient of common air: it abounds in animal substances: The following are its characteristics:

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* Oxygen gas is much more troublesome to make than hydrogen. The cheapest plan is to put a few ounces of manganese (called the black oxide of manganese) into an iron bottle, furnished with a bent tube; set the bottle in a fire till it becomes red hot, and put the end of the tube into a pan of water. In a few minutes, bubbles will rise through the water: these bubbles are oxygen gas.

These bubbles may be collected thus:—Fill a common bottle with water: hold it inverted over the bubbles which rise through the pan, but be sure the mouth of the bottle be held *in the water*. As the bubbles rise into the bottle, the water will run out; and when all the water has run out, the bottle is full of gas. Cork the bottle while the *mouth remains under water*; set the bottle on its base; cover the cork with lard or wax, and the gas will keep till wanted.

N. B.—The *quickest* way of making oxygen gas, is to rub together in a mortar half an ounce of oxide of copper, and half an ounce of chlorate of potassa. Put the mixture into a common oil flask, furnished with a cork which has a bent tube thrust through it. Heat the bottom of the flask over a candle or lamp; and when the mixture is red hot, oxygen gas will be given off. Note—the tube must be immersed in a pan of water, and the gas collected as before.

(Chlorate of potassa may be bought at any chemist's; and oxide of copper may be procured by heating a sheet of copper red hot, and when cool, striking it with a hammer; the scales that peel off, are oxide of copper.)

Exp. Put a piece of red-hot charcoal (fixed to a small piece of wire) into your bottle of oxygen gas; and it will throw out most dazzling sparks of light.

Blow a candle out; and while the wick is still red, hold the candle (by a piece of wire) in the bottle of oxygen gas; the wick will instantly ignite, and burn brilliantly.

(Burning sulphur emits a *blue* flame, when immersed in oxygen gas.)

1. It will not burn;
2. It will not support combustion; and
3. An animal cannot live in it.

Nearly 4 gallons out of every 5 of common air are nitrogen gas.*

Q. *Why is there so* MUCH *nitrogen in the air?*

A. In order to *dilute* the oxygen. If the oxygen were not thus diluted, fires would burn out too quickly, and life would be too rapidly exhausted.

Q. *What three elements are employed in making a common* FIRE?

A. Hydrogen gas, carbon, and oxygen gas: The two former in the *fuel;* and the last in the *air* which surrounds the fuel.

Q. *What causes the combustion of the fuel?*

A. The hydrogen gas of the fuel (being set free and excited by a match) *unites* with the *oxygen* of the air, and makes a yellow flame; this flame heats the

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* Nitrogen gas may easily be obtained thus:—Put a piece of burning phosphorus on a little stand in a plate of water: and cover a bell-glass over it. (Be sure the edge of the glass stands *in the water.*) In a few minutes the *oxygen* of the air will be taken up by the burning phosphorus; and the nitrogen alone will be left in the bell glass.

(N.B.—The white fume which will arise and be absorbed by the water in this experiment, is phosphoric acid; i.e., phosphorus combined with oxygen of the air.)

carbon of the fuel, which unites with more oxygen, and produces *carbonic acid gas.*

The gas of the fuel is carburetted hydrogen. The flame of pure hydrogen is pale *blue*—of carburetted hydrogen *yellow.*

Q. *What is* CARBONIC ACID GAS?

A. Carbon (or charcoal) combined with oxygen gas.

Q. *Why does* FIRE *produce* HEAT?

A. Because it liberates *latent heat* from the air and fuel, by chemical action.

Q. *What* CHEMICAL CHANGES *in air and fuel are produced by* COMBUSTION?

A. 1st—Some of the oxygen of the air, combining with the *hydrogen* of the fuel, condenses into *water:* and

2ndly—Some of the oxygen of the air, combining with the carbon of the fuel, forms *carbonic acid gas.*

Q. *Why is a* FIRE *(after it has been long burning)* RED HOT?

A. Because the whole surface of the coals is so thoroughly heated, that every part of it is undergoing a rapid union with the oxygen of the air.

Q. *In a* BLAZING *fire, why is the* UPPER *surface of the* COALS BLACK, *and the* LOWER *surface* RED?

A. Because carbon (being solid) requires a great degree of heat to make it unite with the oxygen of the air. In consequence of which, the hot *under* surface of coals is frequently *red* from its union with oxygen, while the cold *upper* surface remains *black.*

Q. *Which burns the more quickly, a* BLAZING *fire, or a* RED-HOT *one?*

A. Fuel burns quickest in a *blazing* fire.

Q. *Why do* BLAZING COALS BURN QUICKER *than red-hot ones?*

A. Because the inflammable *gases* of the fuel (which are then *escaping*) greatly assist the process of combustion.

Q. *Why do the coals of a* CLEAR BRIGHT *fire burn out more slowly, than blazing coals?*

A. Because most of the *inflammable gases,* and much of the *solid fuel,* have been consumed already; so that there is less food for combustion.

Q. *What is* SOOT?

A. *Unconsumed* carbon of the fuel separated from the solid mass, and carried up the chimney by currents of hot air.

Q. *What is* SMOKE?

A. Unconsumed volatile matters, separated from the fuel, and carried up the chimney by currents of hot air.

This volatile matter consists of visible vapour, various gaseous exhalations, and minute pieces of carbon.

Q. *Why is there* MORE SMOKE *when* COALS *are* FRESH *added, than when they are red hot?*

A. Because *more carbon* and volatile matters are *separated* from the fuel than can be *reduced by combustion;* and the surplus flies off in smoke.

Q. *Why is there so* LITTLE SMOKE *with a* RED-HOT *fire?*

A. Because the *entire surface* of the coals is in a *state of combustion;* and, as very little of the escaping carbon remains unconsumed, there is but little smoke.

Q. *Why are there* DARK *and* BRIGHT *spots in a* CLEAR *cinder fire?*

A. Because the *intensity* of the combustion is *greater in some parts* of the fire, than it is in *others.*

Q. *Why is the intensity of combustion in a common fire so* UNEQUAL?

A. Because air flies to the fire in various and unequal currents.

Q. *Why do we see all sorts of* GROTESQUE FIGURES *in hot* COALS?

A. Because the *intensity* of combustion is *unequal*, owing to the gusty manner in which the air flies to the fuel: And the various shades of red, yellow, and white heat (mingling with the black of the unburnt coal,) produce strange and fanciful resemblances.

Q. *Why does* PAPER BURN *more readily than wood?*

A. Because it is of a *more fragile texture;* and, therefore, its component parts are more easily heated.

Q. *Why does* WOOD BURN *more readily, than coal?*

A. Because it is not so *solid*; and, therefore, its elemental parts are more easily separated, and made hot.

Q. *When a* FIRE *is* LIGHTED, *why is* PAPER *laid at the* BOTTOM, *against the grate?*

A. Because paper (in consequence of its fragile texture) very readily catches fire.

Q. *Why is wood laid on the top of the paper?*

A. Because wood (being more *substantial*) *burns longer* than paper; and, therefore, affords a *longer* contact of *flame* to heat the coals.

Q. ***Why would not paper do* WITHOUT *wood?***

A. Because paper burns out so *rapidly*, that it would not afford sufficient *contact of flame* to heat the coals to combustion.

Q. ***Why will not wood do* WITHOUT *shavings, straw, or paper?***

A. Because wood is too *substantial* to be heated into combustion by the feeble flame issuing from a *match.*

Q. ***Why would not the paper do as well, if placed on the* TOP *of the coals?***

A. Because every blaze *tends upwards;* if, therefore, the paper were placed on the *top* of the coals, its blaze would afford *no contact of flame* to the fuel lying *below.*

Q. ***Why should* COAL *be placed* ABOVE *the wood?***

A. Because otherwise, the *flame* from the wood would not rise through the *coal*, to heat it.

Q. ***Why is a fire* KINDLED *at the* LOWEST BAR *of a grate?***

A. That the flame may *ascend through the fuel* to heat it. If the fire were kindled from the *top*, the flame would *not come in contact* with the fuel placed below.

Q. *Why does* COAL *make such* EXCELLENT FUEL?

A. Because it contains a large amount of *carbon* and *hydrogen* gas, in a compact and convenient form.

Q. *Why will cinders become* RED HOT *more quickly than* COALS?

A. Because they are sooner reduced to a state of combustion, as they are *more porous* and *less solid.*

Q. *Why will not* IRON CINDERS *burn?*

A. Because the *carbon* and *hydrogen* have been chiefly consumed, and only the incombustible part of the fuel remains.

Q. *Why are* CINDERS *lighter than* COALS?

A. Because they are full of little holes or pores; from which gases, and other volatile parts, have been driven off by *previous combustion.*

Q. *Why will not* STONES *do for fuel, as well as* COALS?

A. Because they contain no elements suitable for combustion: and generally the substances of which they are composed are already *united* to *oxygen*.

Stones contain silex (i.e., silicon and oxygen); alumina (i.e., aluminum and oxygen); and lime (i.e., calcium and oxygen). Some rocks contain sulphur, or a little carbon; in which case they burn feebly.

Q. *Why will not* WET *kindling light a fire?*

A. 1st—Because the moisture of the wet kindling prevents the *oxygen of the air from getting to the fuel;* and

2ndly—The heat of the fire is perpetually *drawn off*, by the conversion of *water* into *steam*.

Q. *Why does* DRY *wood burn better than* GREEN?

A. 1st—Because none of its heat is *carried away* by the conversion of *water* into *steam;* and

2ndly—The pores of dry wood (being *filled with air*) supply the fire with oxygen.

Q. *Why does* SALT CRACKLE, *when thrown into a* FIRE?

A. Salt contains *water*. The *crackling* of burning salt is owing to the bursting of the crystals, when the water is converted into steam.

Q. *Why will not wood or paper burn if*

steeped in a solution of POTASH, *phosphate of* LIME *or* AMMONIA *(hartshorn)?*

A. Because any "al'kali," (such as potash) will *arrest the hydrogen* which escapes from the fuel, and prevent its *combination* with the *oxygen of air.*

Q. *What is an al'kali?*

A. A substance which will neutralize an acid.

Soda, potash, and ammonia, are all alkalis. The presence of an alkali may be detected thus:—Vegetable *blues* will be turned *green* by it; and turmeric paper will be turned *brown* by it.

Q. *Why does a* JET *of* FLAME *sometimes burst into the room through the* BARS OF *a* STOVE?

A. Because the iron bars conduct heat to the *interior of some lump of coal;* and its volatile gas (bursting through the weakest part) is kindled by the glowing coals over which it passes.

Q. *Does the* JET *of* GAS *ever escape unburnt?*

A. Yes. If the gas passes at once into the air, or over coals not sufficiently heated to ignite it.

Q. *Why does a* BLUISH FLAME *sometimes flicker on the surface of hot cinders?*

A. Because the gas from the hot coals at the *bottom of the grate*, mixing with the *carbon of the coals* above, produces an inflammable gas (called carbonic oxide), which burns with a blue flame.

Q. *Why is the* FLAME *of a fire or candle* YELLOW?

A. The flame of a fire or candle is due to a gas called carburetted hydrogen, which burns with a *yellow flame.*

Carburetted hydrogen is a compound of carbon and hydrogen.

Q. *What is* LIGHT?

A. The unknown cause of ***visibility*** The most usual method of obtaining artificial light is by combustion accompanied with flame.

The two theories of light most usually received are those of Newton and Huyghens. According to Sir Isaac Newton, luminous particles of an elastic imponderable fluid, called *ether*, dart in all directions from the surface of light-giving bodies like the sun. Much the same as odour from a flower. According to Huyghens, the aforesaid ether is merely a *vehicle*, or medium, of light, just as air is a medium of sound. As a sonorous substance communicates its vibrations to the atmosphere, and the atmosphere to the tympanum of the ear, so atoms of matter, set in motion by heat, communicate vibrations to the luminous ether, and the luminous ether, impinging against the eye, produces there a sensation of light

Such are the theories of Newton and Huyghens, but it is highly probable that ere long electricity or magnetism will be found to be the cause of light, and that the notion of a luminous ether will be wholly discarded.

Q. *Does* LIGHT *always produce* HEAT?

A. No; *phosphorescent* bodies, certain animals, as glow-worms, also wood, meat, and fish, in a state of putrefaction, produce light unaccompanied with any perceptible heat.

The same may be said of some *chemical* phenomena, as in the combustion of the oxide of carbon and of chlorine.

Q. *Does* HEAT ALWAYS *produce light?*

A. No; many substances, *particularly metals*, may be greatly heated without producing light.

Heat is by no means always proportionate with the intensity of *light* For example: the flame of the bicarbonate of hydrogen is more brilliant than that of *pure* hydrogen, but the heat produced from the latter is considerably greater than that which proceeds from the former. The flame which produces the greatest degree of *heat* is that which results from the ignition of one volume of oxygen and two of hydrogen, nevertheless this flame is scarcely *visible* in daylight.

Q. *Why is a* YELLOW FLAME *brighter than a* RED-HOT COAL?

A Because *yellow rays* produce the greatest amount of *light*, though *red rays* produce the greatest amount of heat.

Q. *Why is the* LIGHT *of a fire* MORE INTENSE *sometimes than it is at others?*

A. The *intensity* of fire-light depends upon the *whiteness* to which the carbon is reduced by combustion. If carbon be *white hot*, its *combustion is perfect*, and the light intense; if not, the light is obscured by *smoke*.

Q. *Why will not* CINDERS BLAZE, *as well as* FRESH *coals?*

A. The *flame* of coals is caused by the burning of *carburetted hydrogen gas*. As soon as this gas has been consumed, the hot cinders produce only a gas, called carbonic acid, which is not combustible.

Q. *Where does the carburetted hydrogen gas of a blazing fire come from?*

A. From the fuel, which is *composed* of carbon and hydrogen; these elements separate from each other during the process of combustion, and form into *new compounds*. (See p. 35.)

Fuel which will not blaze (as coke, cinders, charcoal, &c.), is devoid of hydrogen gas. Yet if sulphur be present in any fuel, it will blaze to some extent.

Q. *Why do coals burn out faster on a* FROSTY NIGHT, *than upon any other?*

A. 1st—Because air *condensed* by the cold contains more oxygen than the same quantity of warmer air; and

2ndly—Air condensed by the cold is *heavier;* in consequence of which; it falls more quickly on the fire, to supply the place of hot ascending air.

Q. *Why does a* FIRE *burn* CLEAREST *on a* FROSTY *night?*

A. Because the *volatile gases* are more quickly consumed; and the solid carbon is *plentifully supplied with oxygen* from the air, to make it burn brightly and intensely.

Q. *Why does a* FIRE *burn more intensely in* WINTER *than in* SUMMER?

A. Because the air is *colder* in winter, than it is in summer.

Q. *Why does the* COLDNESS OF THE AIR *increase the heat of a fire?*

A. 1st—Because air condensed by the cold supplies more *oxygen* than a similar volume of warmer air: and

2ndly—Condensed air, being *heavy,* falls more rapidly into the place of the hot ascending air, to supply the fire with nourishment.

Q. *Why does the* SUN, *shining on a* FIRE, *make it* DULL, *and often put it out?*

A. 1st Because the air (being

rarefied by the sunshine) *flows more slowly to the fire*; and

2ndly—The chemical action of the sun's rays is detrimental to combustion.

The sun's rays are composed of three parts; lighting, heating, and actinic or chemical rays. The two latter interfere with the process of combustion.

Q. *Why does air flow to the fire more* TARDILY *for being* RAREFIED?

A. Because the greater the *contrast* between the *external air*, and that which has been *heated by the fire*, the more *rapid* will be the current of air towards that fire.

Q. *Why does rarefied air afford less* NOURISHMENT *to the fire than cold air?*

A. Because rarefied air contains less *oxygen*, than the same bulk of condensed air.

Inasmuch as the same quantity of oxygen is diffused through a larger space.

Q. *Why does a* FIRE *burn more fiercely in the* OPEN AIR?

A. 1st—Because the *air out-of-doors* is more *dense*, than the air in-doors; and

2ndly—It has freer *access* to the fire.

Q. *Why is the air out-of-doors more* DENSE *than that in-doors?*

A. Because it has freer circulation;

and, as soon as any portion has been *rarefied*, it instantly escapes, and is supplied by *colder currents*.

Q. *Why does not a* FIRE *burn so freely in a* THAW, *as in a* FROST?

A. Because the air is laden with *vapour;* in consequence of which, it both *moves too slowly*, and is too much *rarefied* to nourish the fire.

Q. *Why does a* FIRE *burn very fiercely in* WINDY *weather?*

A. Because *the air is rapidly changed*, and affords plentiful nourishment to the fire.

Q. *Why does a pair of* BELLOWS *get a fire up?*

A. Because it *drives the air more rapidly to the fire;* and the plentiful supply of oxygen soon makes it burn intensely.

Clarke's Patent Blower is to be preferred, because it produces a continuous blast.

Q. *Why is the flame of a candle* EXTINGUISHED, *when blown by the breath; and not made more intense, like a fire?*

A. Because the flame of a candle is confined to a *very small wick*, from which it is severed by the breath; and (being unsupported) *must go out.*

Q. *Why is a* SMOULDERING WICK *sometimes* RE-KINDLED *by blowing it?*

A. Because air is carried to it by the breath with *great rapidity;* and the oxygen of the air kindles the red-hot wick, as it would kindle charred wood.

Q. *Why is not the red-hot wick kindled by the* AIR AROUND *it, without* BLOWING?

A. Because oxygen is not supplied with sufficient freedom, unless air be *blown* to the wick.

Q. *When is this experiment most likely to succeed?*

A. In *frosty* weather; because the air contains more oxygen, when it is *condensed by the cold.*

Q. *Why does a* POKER, LAID ACROSS *a dull* FIRE, *revive it?*

A. For two reasons: 1st—Because the poker *concentrates the heat,* and throws it on the fuel: and

2ndly—Air is directed between the poker and the coals, and a slight *draught* created.

Q. *Why are the grates of modern* STOVES *fixed near the* FLOOR *of a room?*

A. That the air *on the lower part of the room* may be heated by the fire.

Q. *Is not the air of the lower part of a room heated equally well, when the grates are fixed higher up?*

A. No; the heat of a fire has a very little effect upon the air *below the level of the grate;* and, therefore, every grate should be as *near to the floor* as possible.

Q. *Our* FEET *are very frequently* COLD, *when we sit close by a good fire: explain the reason of this.*

A. Because *cold air* rushes through the crevices of the doors and windows *along the bottom of the room*, to supply the place of that heated by the fire which ascends with the smoke; and these currents of cold air, *rushing constantly over our feet*, deprive them of warmth.

Q. *If a piece of* PAPER *be laid flat on a clear fire, it will* NOT BLAZE, *but* CHAR. *Why so?*

A. Because the carbon of a clear fire, being sufficiently hot to unite with the oxygen of the air, *produces carbonic acid gas*, which soon envelopes the paper laid flat upon the cinders: but carbonic acid gas will neither *blaze*, nor allow combustible matter surrounded by it to do so.

Q. *If you* BLOW *the paper, or open the door suddenly, it will* BLAZE *immediately. Why so?*

A. Because the carbonic acid is *dissipated*, and the paper fanned into flame.

Q. *Why does* WATER EXTINGUISH *a* FIRE?

A. 1st—Because it *forms a coating* over the fuel, which keeps it from the air: and

2ndly—The conversion of water into *steam*, draws off the *heat* of the burning fuel.

Q. *A* LITTLE WATER *makes a fire* FIERCER, *while a* LARGER *quantity of water puts it* OUT: *Explain how this is.*

A. A *little* water is readily converted into *steam*, which increases the heat of a fire; but water plentifully supplied is not converted into steam, and stops combustion.

Q. *When the* COALS *upon a fire are small and* DUSTY, *why are they sometimes sprinkled with water?*

A. Because water makes the mass more solid, and the steam assists to heat the coals into perfect combustion.

Q. *When a house is on fire, is too* LITTLE *water worse than* NONE?

A. Certainly. Unless water be supplied so plentifully as to *quench the fire*, it will increase its *intensity*.

Q. *When will water* EXTINGUISH FIRE?

A. When the supply is so rapid and abundant, that the fire cannot convert it into steam.

Q. *Does not a very* LITTLE *water* SLACKEN *the heat of fire?*

A. Yes, *till it is converted into steam*; it then increases the *intensity* of fire.

Q. *Why does the* WICK *of a candle (when the flame has been blown out) very readily* CATCH FIRE?

A. Because it is already *hot*, and a very little *extra* heat will throw it into flame.

Q. *Why does the* EXTRA *heat revive the flame?*

A. Because it again liberates the *hydrogen* of the tallow, and ignites it.

Q. *Cannot* WOOD *be made to* BLAZE *without actual contact with fire?*

A. Yes; if a piece of wood be held *near* a fire for a little time, it will blaze, even though it does not *touch* it.

Q. *Why will* WOOD BLAZE, *even if it does not touch fire?*

A. Because the heat of fire *drives out the hydrogen gas* of the wood; which gas is inflamed by the fire.

Q. *Why will a* NEIGHBOUR'S HOUSE *sometimes* CATCH FIRE, *though no flame of the burning house ever touches it?*

A. Because the heat of the burning house sets at liberty the *hydrogen gas* of the neighbouring wood-work; and this gas is ignited by the flames or red-hot bricks of the house on fire.

The gas referred to in both these answers, is not *pure*, but *impure* (or carburetted) hydrogen.

Q. *What is* COKE?

A. Coal freed from its volatile gases, by the action of artificial heat.

Q. *Why does* ARNOTT'S STOVE *sometimes* SMELL *very strongly of* SULPHUR?

A. Because coke contains sulphur; and whenever the draught is not rapid enough *to drive the sulphur up the flue*, it is emitted into the room.

Q. *What is meant by* SPONTANEOUS COMBUSTION?

A. Combustion produced without the application of *flame.*

Q. *Give an example of* SPONTANEOUS COMBUSTION.

A. Coals stowed in the hold of a vessel, and goods packed in a warehouse, will often catch fire of *themselves,*—especially such goods as cotton, flax, hemp, rags, &c.

Q. *Why do such goods sometimes* CATCH FIRE *of themselves?*

A. Because they are piled together in *large masses* in a *damp* state or place.

Q. *Why does this produce spontaneous combustion?*

A. Because the damp produces *decay;* and the great heat of the piled-up mass makes the decaying goods *ferment.*

Q. *How does this* FERMENTATION *produce* COMBUSTION?

A. During fermentation, great heat is produced by chemical action,—a slow combustion ensues,—till at length the *whole pile* bursts into *flame.*

Q. *Why is the* HEAT *of a* LARGE MASS *of goods* GREATER *than that of a smaller quantity?*

A. Because the heat produced cannot

escape through the massive pile; it therefore accumulates, and raises the temperature of the heap.

Q. *Why do* HAY-STACKS *sometimes* CATCH FIRE *of themselves?*

A. Either because the hay was got up *damp;* or else because *rain* has penetrated the stack.

Q. *Why will a hay-stack* CATCH FIRE, *if the hay be damp?*

A. Because damp hay soon *decays*, and undergoes a *state of fermentation*, during which great heat is produced, and the stack catches *fire*.

Q. *Is the* HAY *in a stack* INJURED *by* "HEATING," *if it does not* CATCH FIRE?

A. Yes; it is frequently *charred* and turned black; which renders it unfit for use.

Q. *If a hay-stack is found to be "heating," what can be done to prevent its catching fire, or spoiling the* HAY?

A. It may be taken down and re-formed into a stack after it has been further dried: or a chimney may be formed in the middle of the stack to carry off the heat.

CHAPTER IV

SMOKE.

Q. *Why does smoke* ASCEND *a chimney?*

A. Because the air of the room passing over the fire, becomes lighter for being *heated;* and (being thus made *lighter*) ascends the chimney, carrying the smoke with it.

Q. *Why does lighter heated air ascend in a chimney?*

A. Because the heavier cold air in the room presses it up.

Q. *What determines the rapidity or strength of the draught in a chimney?*

A. The difference of weight between the *cold air* which supplies the fire, and the *hot air* in the chimney flue.

Q. *Why is the draught of a short flue more slack than that of a long one?*

A. Because the *shorter* the *flue*, the *less difference* of weight is there between the ascending current, and the air which presses it up the chimney.

If chimneys are too high, in comparison *with the size of the fire*, the ascending air gets *cold* before it reaches the top: and the draught is injured.

Q. *Why do* SMOKE *and* STEAM *assume a wreathy or curly form?*

A. Because they are pushed round and round by ascending and descending currents of air.

Q. *What are* BLACKS?

A. Smoke condensed into flakes, which fall to the earth by their own weight.

Q. *Why are there no blacks thrown from the funnel of a railway engine?*

A. Because *condensed steam* alone escapes from the railway engine, which is *dissolved* by the air.

The fuel burnt in the furnace is so perfectly consumed, owing to the sharpness of the draught, that very little deposit of soot can take place.

The black deposit, which sometimes annoys the railway traveller, arises from water thrown through the chimney of the locomotive, made dirty in its passage.

Q. *Why does a* "FURNACE-FIRE" DRAW *up more fiercely than an* OPEN *stove?*

A. Because the air, which supplies the fire, must pass *through the* *furnace;* and, as it becomes exceedingly *heated*, rushes up the chimney with great violence.

Q. *What produces the* ROARING *noise made by a* FURNACE *fire?*

A. Air rushing rapidly through the crevices of the *iron door*, and up the *chimney flue.*

Q. *Why is the* ROAR *less if the furnace* DOOR *be thrown* OPEN?

A. Because *fresh air* gets access to the fire *more easily;* and, as the air is not so intensely heated, its motion is not so *violent.*

Q. *Why do some* CHIMNEYS SMOKE?

A. Because fresh air is not admitted into the room *so fast as it is consumed by the fire;* in consequence of which, a current of air *passes down the chimney* to *supply the deficiency*, driving the smoke along with it.

Q. *What things would prevent air from being supplied as fast as it is consumed by the fire?*

A. Leather and curtains round the doors; sand-bags at the threshold and on the window frames; and other contrivances to keep out the draught.

Q. *Why will the air come down the chimney?*

A. Because it can get to the fire in no *other* way, if the doors and windows are all made *air-tight.*

Q. *What is the best* REMEDY *in such a case?*

A. The *speediest* remedy is to open the door or window; but by far the *best* remedy is to carry a small tube from the hearth into the external air.

Q. *Why is that the* BEST *remedy?*

A. Because the fire will be plentifully supplied with air by the tube: the doors and windows may all remain air-tight; and we may enjoy a warm fire-side, without the inconvenience of draughts and cold feet.

Q. *Why is a* CHIMNEY *raised so high above the* ROOF*?*

A. That it may not smoke; as all funnels do, which are too short.

Q. *What is meant by the* FUNNEL *or* FLUES *of a chimney?*

A. That part of a chimney through which the *smoke passes.*

Q. *Why does a* CHIMNEY SMOKE, *if the funnel be very short?*

A. Because the *draught* of a short flue is *too slack* to carry the smoke up the chimney.

Q. *On what does the intensity of fire depend?*

A. The *intensity* of fire is always in proportion to the *quantity of oxygen* with which it is supplied.

Q. *Does the* DRAUGHT *of a chimney depend on the* SPEED *of the* SMOKE *through the flue?*

A. Yes. The more quickly *hot* air flies *up a chimney*, the more quickly *cold* air will rush *towards the fire* to supply its place; and, therefore, the *longer the flue*, the *greater the draught.*

Q. *Why are the* CHIMNEYS *of* MANUFACTORIES *made so very* LONG?

A. To increase the intensity of the fire.

Another reason for this arrangement is to prevent the annoyance caused by the smoke and unwholesome gases, when they escape too near to inhabited dwellings.

Q. *Why is the* INTENSITY *of a fire increased by* LENGTHENING *a* FLUE?

A. Because the draught being greater, more *fuel* is consumed in the same time;

and, of course, the *intensity* of the heat is proportionally greater.

Q. *If a* SHORT CHIMNEY *cannot be lengthened, what is the best* REMEDY *to prevent smoking?*

A. To *contract the opening of the chimney* contiguous to the stove.

Q. *Why will a* SMALLER OPENING *above the stove,* PREVENT *a chimney's* SMOKING?

A. Because the air will be compelled to pass *nearer the fire;* and (being more *heated*) will rise through the chimney more rapidly: This *increase of heat* will, therefore, compensate for the *shortness* of the *flue.*

Q. *Why will a* ROOM SMOKE, *if there be* TWO FIRES IN IT?

A. Because the *fiercer* fire will exhaust the most air; and may draw from the *smaller* one, to supply its demand.

This inconvenience does not arise in large rooms, with fire properly adjusted.

Q. *Why will a chimney* SMOKE, *if there be a fire in* TWO ROOMS *communicating with each other?*

A. Because (whenever the *door* between the two rooms is *opened*) air will rush from the chimney of the inferior fire to supply the *other*; and *both* rooms will be filled with smoke.

Q. *What is the best* REMEDY *in this case?*

A. To carry a tube from the hearth of each stove into the external air; and then *each* fire will be so well supplied, that neither will need to borrow from the other.

Q. *Why do* VESTRY *chimneys so often smoke?*

A. Because the wind (striking against the steeple) is reflected back; and rushing down the vestry chimney, forces the smoke *into the room.*

Q. *What* WINDS *make vestry chimneys smoke?*

A. Those from the north-east or south-east; according to the position of the vestry.

Q. *Why will* EAST *winds make* VESTRIES SMOKE, *more than west winds?*

A. Because *east winds strike against the steeple,* and *bound back again* to the vestry chimney: but *west winds* cannot rebound over the roof of a church.

N.B. The *steeple* of a church is always due *west* and the *other* end of the church due *east*; if, therefore, a *west* wind were to rebound, it would rebound to the *west* (or *away from the church*) and not *towards it*.

Q. *Why does a* HOUSE *in a* VALLEY *very often* SMOKE?

A. Because the wind (striking against the surrounding hills) *bounds back again upon the chimney*, and destroys its draught.

Q. *What is the* COMMON REMEDY *in both these cases?*

A. To fix a *cowl* on the chimney-top, to turn like a weather-cock, and present its back to the wind.

Q. *Why will not a* COWL *always* PREVENT *a chimney* SMOKING?

A. Because a *strong wind* will keep the *opening* of the cowl *towards the steeple or hill;* and then the reflected wind will blow *into the cowl* and *down the chimney.*

Q. *As a cowl is such a poor remedy, what* OTHER *can be suggested?*

A. If the chimney-flue can be carried *higher* than the steeple or hills, no wind can enter the flue.

Q. *If a chimney-flue be carried up* HIGHER *than the steeple or hill, why cannot the wind enter it?*

A. Because the reflected wind would strike against the *sides* of the chimney-flue, and not pass over its *opening* at all.

Q. *In what* OTHER *cases will a* CHIMNEY SMOKE?

A. If the door and stove are both placed on *the same side of a room*, the chimney will often smoke.

Q. *Why will a* CHIMNEY SMOKE, *if the* DOOR *and* STOVE *are both on the* SAME SIDE?

A. Because (whenever the door is opened) a current of air will *blow obliquely into the chimney-place*, and drive the smoke into the room.

Q. *What* REMEDY *can be applied to this evil?*

A. The door must be set *opposite* to the chimney-place, or nearly so; and then the draught from the door *will blow the smoke up the chimney*, and not into the room.

Q. *Why will a* CHIMNEY SMOKE *if it needs* SWEEPING?

A. Because loose soot obstructs the free passage of the smoke, *checks* the *current*, and prevents the draught.

Q. *Why will a* CHIMNEY SMOKE *if it be* OUT OF REPAIR?

A. 1st—Because the *loose mortar and bricks* obstruct the smoke: and

2ndly—*Cold air* (oozing through the

chinks) *chills the air in the chimneys*, and prevents its ascent.

Q. *Why will an* ARNOTT'S STOVE SMOKE, *if the joints of the flue do not fit air-tight?*

A. Because *cold air* (oozing through the joints) *chills the air in the flue*, and prevents its ascent.

Q. *Why does an old-fashioned* FARM CHIMNEY-PLACE *generally smoke?*

A. Because the opening is so *very large*, that much of the air which goes up the chimney, *has never passed near the fire;* and this cold air (mixing with the hot) so *reduces its temperature*, that it ascends very slowly, and the draught is destroyed.

Q. *Why does a chimney* SMOKE *if the* DRAUGHT *be* SLACK?

A. Because the current of air up the chimney is not powerful enough to *buoy up the smoke* through the flue.

Q. *If the opening of a chimney be* TOO LARGE, *what* REMEDY *can be applied?*

A. The chimney-place must be contracted.

Q. *Why will* CONTRACTING *the chimney-place* PREVENT *its* SMOKING?

A. Because the air will then pass *nearer the fire;* and (being *more heated*) fly faster up the chimney.

Q. *Why do almost all* CHIMNEYS SMOKE *in* GUSTY *weather?*

A. Because the column of smoke is suddenly chilled by the wind, and (being unable to ascend) rushes back into the room.

Q. *What is the use of a* CHIMNEY-POT?

A. To increase the draught, when the opening of a chimney is too *large.*

Q. *How does a chimney-pot* INCREASE *the* DRAUGHT *of a chimney?*

A. 1st—By diminishing the aperture of the funnel, and thus preventing cold air from entering the chimney to chill the warm ascending air: and

2ndly—By lengthening the flue, and increasing the draught.

Q. *Why do* TIN-BLOWERS *help to get a fire up?*

A. Because they compel the air to

go *through* the fire, and not *over* it; in consequence of which, the fire is well supplied with oxygen, and the draught greatly increased.

Q. *Why does a* BLOWER INCREASE *the* DRAUGHT?

A. Because it compels the air to pass *through* the fire; and, being made much hotter, it ascends the chimney more rapidly.

Q. *Why is a fire better supplied with oxygen while the blower hangs before it?*

A. Because the draught is increased; and the faster the *hot* air flies *up the chimney*, the faster will *cold air rush towards the fire*, to supply it with oxygen.

Q. *Why does a parlour often* SMELL *disagreeably of* SOOT *in* SUMMER TIME?

A. Because the air in the *chimney* (being *colder* than the air in the *parlour*) *descends into the room*, and leaves a disagreeable smell of soot behind.

Q. *Why are the* CEILINGS OF PUBLIC OFFICES *generally* BLACK *and filthy?*

A. Because the heated air of the office

carries up the dust and fine soot; which is deposited on the ceiling.

Q. *Why are* SOME *parts of the ceiling* BLACKER *and more filthy than others?*

A. Because the ceiling, by the drying of the plaster, becomes uneven, and the currents of air which pass over it, deposit the dust or fine soot on the more prominent parts.

Q. *What is* CHARCOAL?

A. Wood which has been exposed to a red heat, till it has been deprived of all its gases and volatile parts.

Q. *Why is a* CHARCOAL FIRE *hotter than a wood fire?*

A. Because charcoal is nearly pure carbon, while wood contains other elements; and, as it is the *carbon* of fuel which produces the glowing heat of combustion, therefore, the purer the carbon, the more intense will the heat of a fire be.

Q. *Why does charcoal* REMOVE *the* TAINT *of meat?*

A. Because it absorbs all putrescent

effluvia, whether they arise from animal or vegetable matter.

Q. *Why is* WATER PURIFIED *by being filtered through charcoal?*

A. Because charcoal absorbs the *impurities* of water, and removes all disagreeable tastes and smells, whether they arise from animal or vegetable matter.

Q. *Why are water and wine casks* CHARRED *inside?*

A. Because *charring* the inside of a cask reduces it to a kind of *charcoal;* and charcoal (by absorbing animal and vegetable impurities) keeps the liquor sweet and good.

Q. *Why does a piece of* BURNT BREAD *make impure water more fit to drink?*

A. Because the surface of the bread (which has been reduced to charcoal by being burnt) corrects the impurities of the water, and makes it palatable.

Q. *Why should* TOAST *and* WATER, *placed by the side of the sick, be made of* BURNT *bread?*

A. Because the charcoal surface of

burnt bread prevents the water from being affected by the impurities of a sick room.

Q. *Why are* TIMBERS, *which are to be exposed to damp,* CHARRED? *

A. Because *charcoal undergoes no change* by exposure to air and water: in consequence of which, timber will resist weather *much longer,* after it has been charred.

Q. *Why are* POSTS, *which are fixed in the ground,* CHARRED?

A. Because charred wood resists decay, (which would otherwise affect the part underground,) from the *moisture* of the earth.

Q. *What precaution is necessary in charring posts?*

A. To continue the "charring" beyond the part buried in the ground; lest the post should decay at the *base,* from rain and other moisture on the earth's surface.

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* **The post should be charred to about one foot above the ground.**

CHAPTER V.

LAMPS AND CANDLES.

Q. *Of what are* OIL, TALLOW, *and* WAX *composed?*

A. Principally of carbon and hydrogen gas. The *solid* part is carbon, the *volatile* part is hydrogen gas.

Oxygen also, in small proportions, enters into the composition of some substances used for candles.

Q. *What is* CARBON?

A. A solid substance, generally of a black colour; well known under the forms of charcoal, lamp-black, coke, &c.

Q. *What is* HYDROGEN GAS?

A. One of the elements of water. It burns so readily, that it used to be called "inflammable air."*

Common coal gas is a compound of carbon and hydrogen, called "carburetted hydrogen." See p. 203.

Q. A CANDLE BURNS *when lighted—Explain how this is.*

A. The heat of the lighted wick *decomposes the tallow or wax;* and forms vapour of water, and carbonic acid gas.

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* Directions for making hydrogen gas are given on p. 87.

Q. *How are vapour of water and carbonic acid gas formed from the burning tallow or wax of a candle?*

A. The *hydrogen* of the candle, combining with the *oxygen* of the air, forms *vapour of water:* and the *carbon* of the candle, combining with the *oxygen* of the air, forms *carbonic acid gas.*

Q. WHERE *is the tallow or wax of a candle decomposed?*

A. In the *wick.* The melted tallow, or wax, *rises up the wick* by capillary attraction, and is rapidly decomposed by the heat of the flame.

Q. *What is* CAPILLARY ATTRACTION?

A. The power which very minute tubes possess, of causing a liquid to rise in them above its level.

"Capillary," from the Latin word, "capillaris" (*like a hair*); the tubes referred to are almost as fine and delicate as a hair.

Water ascends through a lump of sugar, or piece of sponge, by capillary attraction. N.B. The smaller a tube, the higher will a liquid be attracted in it.

Q. *Why is the* FLAME *of a candle* HOT?

A. Because it liberates *latent heat* from the air and tallow.

Q. *How is* LATENT HEAT *liberated by the flame of a candle?*

A. When the elements of the tallow combine with the *oxygen* of the air, latent heat is liberated by the chemical changes.

Q. *Why does the flame of a* CANDLE *produce* LIGHT?

A. Because the chemical changes made by combustion, excite *undulations of luminous ether*, which (striking the eye) produce light. (See p. 47.)

Q. *Describe the different parts of the flame of a common* CANDLE.

A. The flame consists of *three* cones: The *inner* or *hollow* cone, in which no combustion takes place;—the *intermediate* cone or *area* of partial combustion, in which the *hydrogen* is chiefly consumed;—and the *outer* cone or *area* of perfect combustion, in which the *carbon* is principally burned.

Q. *Why does the* INSIDE *of the flame appear* HOLLOW?

A. Because it is filled with *invisible vapour* raised from the candle by the heat of the wick; which cannot be burnt unless in contact with the air.

Q. *From which part of the flame is the greatest illuminating power derived?*

A. From the *intermediate* cone, in which the burning gas raises the particles of carbon to a *white heat*; upon which the illuminating power depends.

Q. *Why, for the most part, is only the hydrogen consumed in the intermediate cone?*

A. Because the *oxygen* of the air has a *greater affinity for hydrogen* than for carbon; and that which penetrates to this part of the flame, not being *sufficient* to combine with *both*, unites with *hydrogen* to form *water*.

Q. *Why is the* MIDDLE CONE *in a state of less perfect combustion than the outer?*

A. Because the *outer cone* prevents the *oxygen of the air* from getting freely to the middle of the flame; and without free access of oxygen, there cannot be complete combustion.

Q. *Why is the* OUTER *of less illuminating* POWER *than the* INTERMEDIATE *cone?*

A. Because the *incandescent carbon*, which passes to the *outer* cone, is immediately consumed by combining with the oxygen of the air, to form *carbonic acid gas*.

"Incandescent," that is, heated to whiteness.

Q. *Why is the* BOTTOM *of the flame purple?*

A. Because it contains very little incandescent carbon, on which the illuminating power of a candle depends.

Q. *Why does the flame of a candle point* UPWARDS?

A. Because it *heats the surrounding air*, which (being hot) *rapidly ascends*, carrying the flame upwards at the same time.

Q. *Why is the* FLAME *of a candle* POINTED *at the top, like a cone?*

A. Because, as the cone of heated vapour rises, it is *consumed;* and its surface being *diminished*, a *pointed form* is given to the flame.

"Consumed," that is, converted into vapour of water and carbonic acid gas.

Q. *Why is the* FLAME *of a candle* BLOWN OUT *by a puff of breath?*

A. Because it is *severed from the wick*, and goes out for want of support.

Q. *Why does the* FLAME *of a candle make a glass (which is held over it)* DAMP?

A. Because a "watery vapour" is made, by the combination of the *hydrogen of the tallow* with the *oxygen of the air;*

which is condensed by the *cold glass*, held above the flame.

Water is composed of oxygen and hydrogen gases, chemically united.

Q. *Why does the hand, held* ABOVE *a candle, suffer more from heat, than when it is placed* BELOW *the flame, or on* ONE SIDE *of it?*

A. Because the ascending *heated air* comes in contact with the hand placed *above* the flame; but when the hand is placed *below* the flame or on *one side*, it only feels heat from *radiation*.

"Radiation:" i.e. emission of rays. The candle-flame throws out rays of light and heat in all directions; but when the hand is held *above* the flame, it not only feels the heat of the *rays*, but also of the ascending current of *hot* air.

Q. *Why is a* RUSH-LIGHT *extinguished more quickly than a cotton-wick candle?*

A. Because a hard rush imbibes the melted fat or wax much more slowly than porous cotton; as it imbibes less fat, it supplies a smaller volume of *combustible gases;* the flame is, therefore, smaller, and more easily extinguished.

Q. *Why is it more difficult to blow out a* COTTON *wick, than a rush-light?*

A. Because porous cotton imbibes the melted fat, or wax, much more quickly, than hard rush: as it imbibes more fat, it supplies the flame with a larger volume of *combustible gases;* and, of course, the light is with more difficulty extinguished.

Q. *Why is a* GAS FLAME *more easily extinguished, when the jet is very slightly turned on, than when it is in full stream?*

A. Because there is less volume of combustible gases in the small flame, than in the full blaze.

Q. *Why does an* EXTINGUISHER *put a candle out?*

A. Because the air in the extinguisher is soon *exhausted of its oxygen* by the flame: and when there is *no oxygen*, flame goes out.

Q *Why does not a candle set fire to a* PIECE OF PAPER *twisted into an extinguisher, and used as such?*

A. 1st—Because the flame very soon *exhausts the oxygen* contained in the paper extinguisher: and

2ndly—The flame invests the *inside of the paper extinguisher* with *carbonic acid gas*, which prevents it from blazing.

Q. *Why is a* LONG WICK *never upright?*

A. Because it is bent by its own weight.

Q. A LONG WICK *is covered with an* EFFLORESCENCE *at the top.—What does this arise from?*

A. This knotty or flowery appearance arises from an accumulation of *charred particles* of cotton, which have not been completely burnt, because the oxygen of the atmosphere has been kept from them by the outer cone of the flame.

Q. *Why is not the* END *of a long wick burnt off, as it hangs over the flame?*

A. Because the *length* and *thickness* of the unburnt wick so *diminishes the flame* and *checks combustion*, that there is not *heat* enough to *consume* the charred particles.

Q. *Why do the wicks of Palmer's candles never require snuffing?*

A. Because the wick is divided into two or more parts, which, with the assistance of a *fine wire* twisted with the cotton, spread and project *beyond the flame;* where they are readily consumed.

Immediately the wick reaches the *outer cone* of the flame it is consumed, because the supply of oxygen is very plentiful there.

Q. *Why do common candles require to be snuffed?*

A. Because the wick is surrounded by the *outer cone* of the flame, which prevents a sufficient *supply of oxygen* to cause *complete* combustion.

Q. *Why do wax and composite candles never require snuffing?*

A. Because the wick is so platted as to bend into the outer cone, where it is completely consumed.

Q. *Why is this plan not adopted in making tallow candles?*

A. Because the bending of the wick, which causes part of the flame to project, would melt the tallow on one side too quickly, causing the candle to "*gutter.*"

Tallow melts at a lower temperature than wax or stearine; which prevents the employment of this plan for consuming the wick.

Q. *What is the smoke of a* CANDLE?

A. Solid particles of carbon, separated from the wick and tallow, but not consumed.

Q. *Why are* SOME *particles consumed, and not* OTHERS?

A. Because the outer surface of the flame *prevents* the *access of air* to the *interior parts*, whence much of the carbon passes off in smoke.

The *combustion of the carbon* depends upon its *combining with the oxygen of the air.*

Q. *Why do* LAMPS SMOKE?

A. Either because the *wick is cut unevenly*, or else because it is *turned up too high.*

Q. *Why does a* LAMP SMOKE, *when the* WICK *is cut* UNEVENLY?

A. Because the points of the *jagged edge* project into the flame, where the supply of oxygen is not sufficient to consume all the carbon.

Q. *Why does a* LAMP SMOKE, *when the* WICK *is turned up too* HIGH?

A. Because more carbon is separated from the wick, than can be *consumed by the flame.*

Q. *Why do not* "ARGAND BURNERS" *smoke?*

A. Because a current of air passes through the *middle* of the *flame;* in consequence of which, the carbon of the *interior* is consumed, as well as that in the *outer coating* of the *flame.*

Q. *Why does a* LAMP-GLASS DIMINISH *the* SMOKE *of a lamp?*

A. 1st—Because it increases the supply of *oxygen* to the flame, by producing a draught; and

2ndly—It *concentrates* and *reflects* the *heat* of the flame: in consequence of which, the combustion of the carbon is more *perfect*, and very little escapes unconsumed.

CHAPTER VI.

ANIMAL HEAT.

Q. *What is the cause of* ANIMAL HEAT?

A. Animal heat is produced by the *combustion of hydrogen and carbon* in the capillary vessels.

Q. *What are* CAPILLARY VESSELS?

A. Vessels *as small as hairs* running *all over the body;* they are called capillary from the Latin word "capilla'ris" (*like a hair.*)

Q. *Do these* CAPILLARY VESSELS *run all over the human body?*

A. Yes. Whenever *blood flows from a wound*, some blood-vessels must be divided; and, as you can bring blood from any part of the body by a very slight wound, these little vessels must run through every part of the human frame.

Q. *How do* HYDROGEN *gas and* CARBON *get into these very minute vessels?*

A. The food we eat is *converted into blood;* and blood contains both *hydrogen* and *carbon.*

Q. *How does* COMBUSTION *take place in the capillary vessels?*

A. The *carbon of the blood* combines *with the oxygen of the air we breathe,* and forms *carbonic acid gas.*

Q. *What becomes of this* CARBONIC ACID GAS, *formed in the human blood?*

A. The lungs throw off almost all of it into the air, by the act of expiration.

Q. *What* GAS *is generated in a common* FIRE *by* COMBUSTION?

A. *Carbonic acid gas,*—formed by the union of the *carbon of fuel* with the *oxygen of air.*

Q. *What* GAS *is generated by a lighted* CANDLE *or* LAMP?

A. *Carbonic acid gas,*—formed by the union of the *carbon of oil or tallow* with the *oxygen of air.*

Q. *What is the cause of* HEAT *in the* ANIMAL *system?*

A. It is produced by a species of slow combustion in the body.

Q. *Does the* HEAT *of the* HUMAN BODY *arise from the* SAME CAUSE *as the heat of* FIRE?

A. Yes, it does. The *carbon of the blood* combines with the *oxygen of the air inhaled,* and produces *carbonic acid gas.*

Q. *If animal heat is produced by* COMBUSTION, *why does not the human body* BURN UP *like a coal or candle?*

A. It actually does so. Every muscle, nerve, and organ of the body, *wastes away* like a *burning lamp;* and (being reduced to air and ashes) is rejected from the system as useless

Q. *If every bone, muscle, nerve, and organ is thus consumed by combustion, why is not the body entirely* CONSUMED?

A. It would be so, unless the parts destroyed *were perpetually renewed:* but as a lamp will not go out, so long as it is *supplied with fresh oil;* neither will the *body* be consumed, so long as it is *supplied with sufficient food.*

Q. *What is the principal difference between the combustion of a* FIRE *or* LAMP, *and that of the* HUMAN BODY?

A. In the human body, the combustion is affected at a much *lower temperature;* and carried on more *slowly* than in a lamp or fire.

The fire of one's body is not hotter than from 90 to 104 degrees. This heat is, nevertheless, sufficient to burn some things. For example, a little piece of phosphorus will ignite, if it gets by accident under the nail.

Q. *How is it that carbon can be made to burn at so* LOW *a temperature in the human body?*

A. Because the carbon in the blood is reduced to very *minute particles*, ready to undergo a rapid change immediately oxygen is supplied.

Q. *When a man is* STARVED *what parts of the body go first?*

A. First the *fat*, because it is the most combustible; afterwards the *muscles*; and then the man dies, like a *lamp which is burnt out.*

Q. *Why does want of sufficient* NOURISHMENT *often produce* MADNESS?

A. Because while the *fat and muscles* of the body are consuming by animal combustion, the brain also is attacked; and disease is produced in it before it is finally destroyed.

Q. *Why does a man* SHRINK *when* STARVED?

A. Because the capillary fires feed upon the human *body*, when they are not supplied with food-fuel. A starved man shrinks *just as a fire does*, when it is not supplied with fuel.

Q. *What is the* FUEL *of the* BODY?

A. *Food* is the fuel of the body. The *carbon of the food*, combining with the *oxygen of the air*, evolves heat, in the same way that a fire or candle does.

Q. *Why is* EVERY *part of the* BODY WARM?

A. Because the capillary vessels run through every part of the human body, and the combustion of blood *takes place in the capillary vessels.* (*See p* 86.)

Q. *Why does* RUNNING *make us warm?*

A. Because we inhale more air, and cause the blood to pass more rapidly through the lungs. *Running* acts upon blood in the capillary vessels, as a pair of *bellows* on a common fire.

Q. *Why does inhaling air* RAPIDLY *make the body feel* WARM?

A. Because *more oxygen* is introduced into the body. In consequence of which, the combustion of the blood is *more rapid,*—the blood itself *more heated,*—and every part of the body is made warmer.

Q. *Why does* HARD WORK *produce* HUNGER?

A. Because it produces *quicker respiration;* by which means, a *larger amount of oxygen is introduced into the lungs,* and the *capillary combustion increased.* Hunger is the *notice,* (given by our body to remind us, that our *food-fuel* must be *replenished.*

Q. ***Why do want of exercise and too abundant feeding make men fat or ill?***

A. Because more *hydrogen* and *carbon* are taken into the *blood* than can be consumed by the *respiration;* these therefore, either turn to fat, or cause some *disturbance* in the *system*, which is called *disease.*

Q. *Why do* SINGING *and* READING ALOUD *make us feel hungry?*

A. Because they *increase respiration;* and, as *more oxygen* is introduced into the lungs, *our food-fuel is more rapidly consumed*

Q. *Why do we feel less* HUNGRY *in the night, than in the day?*

A. Because we breathe *more slowly during sleep*; therefore, less *oxygen* is introduced into the lungs, to consume our *food-fuel.*

Q. *Why do we need* WARMER CLOTHING *by* NIGHT, *than by* DAY?

A. 1st—Because the *night is generally colder* than the day: and

2ndly—Because we breathe more *slowly:* In consequence of which, animal combustion is retarded, and our bodies are *colder.*

Q. *Why do we* PERSPIRE, *when very hot?*

A. Because the pores of the skin are thrown open to let some of the fluids of the blood escape.

Q. *Why do persons feel* LAZY *and averse to exercise, when they are* HALF-STARVED *or* ILL-FED?

A. Because desire for muscular action *ceases*, when the body is not supplied with nutritious food.

Q. *Why have persons, who follow* HARD OUT-OF-DOORS OCCUPATIONS, *more* APPETITE *than those who are engaged in* SEDENTARY *pursuits?*

A. Because hard bodily labour in the open air *causes much oxygen* to be conveyed into the *lungs by inspiration;* the combustion of the food is carried on quickly; *animal heat increased;* and need for nutritious food more quickly indicated by *craving hunger.*

Q. *Why have persons, who follow* SEDENTARY PURSUITS, *less* APPETITE *than ploughmen and masons?*

A. 1st—Because the air they inhale is *less pure*, being deprived of some of its oxygen: and

2ndly—Their respiration is neither *so quick, nor so strong;* and, therefore, the combustion of their food is carried on more slowly.

Q. *Why do we like strong* MEAT, *and* GREASY *food, when the weather is very* COLD?

A. Because strong meat and grease contain large portions of *carbon* and *hydrogen;* which produce a larger amount of heat (when burned in the blood) than any kind of food.

Q. *Why do persons* EAT MORE *food in cold weather, than in hot?*

A. Because the body requires more fuel in *cold weather,* to keep up the *same amount of animal heat;* and as we put more *coals* on a fire on a cold day, to keep our *room* warm, so we eat more *food* on a cold day, to keep our *body* warm.

Q. *Why does cold produce* HUNGER?

A. 1st—Because the air contains more *oxygen* in cold weather; and, therefore, fires burn *more fiercely,* and *animal combustion is more rapid:* and

2ndly—As we are more *active* in cold weather our increased respiration acts *like a pair of bellows* on the capillary combustion.

Q. *Why does rapid* DIGESTION *produce a craving* APPETITE?

A. This is a wise provision to *keep our bodies in health;* hunger gives notice that the *capillary fires need replenishing,* in order that the *body itself* may not be consumed.

Q. *Why do we feel a desire for* ACTIVITY *in cold weather?*

A. 1st—Because activity increases the warmth of our body, *by fanning the combustion of blood:* and

2ndly—The *strong food* we eat creates a desire for muscular exertion.

Q. *Why are the Esquimaux so passionately fond of* TRAIN OIL, *and* WHALE BLUBBER?

A. Because oil and blubber contain large quantities of *carbon and hydrogen,* which are exceedingly combustible; and the heat of their bodies is increased by the *greasy nature of their food.*

Q. *Why do we feel a* DISLIKE *to strong meat and greasy food in very* HOT *weather?*

A. Because strong meat and grease contain so much *carbon and hydrogen*, that they would make us *intensely hot*; we, therefore, instinctively refuse them in hot weather.

Q. *Why do we like* FRUITS *and* VEGETABLES *most in hot weather?*

A. Because they contain *less hydrogen and carbon* than meat; and, therefore, produce not only *less blood*, but blood of a *less combustible nature.*

Q. *Why is our blood of a less* COMBUSTIBLE *nature, if we live chiefly upon* FRUITS *and* VEGETABLES?

A. Because fruits and vegetables supply the blood with a very large amount of *water;* which is not combustible, like the *carbon and hydrogen* of strong meat.

Q. *How do* FRUITS *and* VEGETABLES COOL *the* BLOOD?

A. 1st—They diminish the amount of *carbon and hydrogen* in the blood, which are the chief causes of animal heat: and

2ndly—They supply the blood with a

large amount of water which exudes *through the skin*, and leaves the body cool.

Q. *Why do we feel* LAZY *and averse to activity in very* HOT *weather?*

A. 1st—Because muscular activity increases the heat of our body, by *quickening respiration:* and

2ndly—The food we eat in hot weather (not being *greasy*) naturally abates our desire for bodily activity.

Q. *Why do the inhabitants of* TROPICAL *countries live chiefly upon* RICE *and* FRUIT?

A. Because rice and fruit (by digestion) are mainly converted into *water;* and (by *cooling the blood*) prevent the tropical heat from feeling so oppressive.

Q. *Why are the* ILL-FED *instinctively averse to* CLEANLINESS?

A. Because cleanliness increases *hunger*, which they cannot allay by food.

The force of bad habits, without doubt, has more to do with this result, than the scientific fact mentioned above.

Q. *Why does the frequent use of* BATHS *generally tend to improve health?*

A. Because it keeps the pores of the body *free from obstruction:* and promotes a healthy performance of the functions of the skin.

Q. *Why are very* POOR *people instinctively* AVERSE *to* VENTILATION?

A. 1st—Because ventilation *increases the amount of oxygen in the air*,—the *combustion of food*, and the *cravings of appetite;* and

2ndly—Ventilation *cools the air* of a *room:* to poor people, therefore, who are ill-clad, the *warmth* of an ill-ventilated apartment is agreeable.

Q. *Why are birds hot-blooded creatures?*

A. Because they breathe *quickly;* and the combustion of their blood is very rapid, from the abundance of oxygen introduced into their bodies.

Q. *Why are children hotter than old people?*

A. Because they breathe *more quickly;* and more oxygen is introduced into their blood to supply the capillary fire.

The heart beats more quickly in the young than in the old. The pulsations are often 140 in a minute in infants; and not more than 70 in a minute in the very aged.

Q. *Are* BEARS *and* DORMICE *colder during their winter sleep?*

A. Yes. Because their breathing and circulation almost cease.

For the same reason they are able to dispense with food for so long a time.

Q. *Why are* FROGS, FISHES, SNAKES, *and* LIZARDS, COLD-BLOODED *animals?*

A. Because they consume very *little air;* and, without a plentiful supply of air, combustion is too slow to generate much animal heat.

Q. *Why is a* DEAD BODY *cold?*

A. Because air is no longer conveyed to the lungs, after respiration has ceased: and, therefore, animal heat *is no longer generated by combustion.*

CHAPTER VII.

MECHANICAL ACTION.

I.—PERCUSSION.

Q. *How is heat produced by* MECHANICAL ACTION?

A. 1.—By Percussion. 2.—By Friction. 3.—By Condensation. And 4.—By Electricity.

Electricity produces heat only when it meets with some *obstruction*. When its force of motion is arrested, it is converted into another force called heat.

N.B. No force can ever be *lost*, but every force may be *changed* into some other.

Q. *What is meant by* PERCUSSION?

A. *The act of striking;* as when a blacksmith strikes a piece of iron on his anvil with his hammer.

Q. *Why will* STRIKING *iron make it red* HOT?

A. Because the force called motion is suddenly arrested, and shows itself in another form, called heat.

Q. *What* EFFECT *has heat on inanimate bodies?*

A. It pushes the particles of the body further apart from each other.

Q. *Give an example.*

A. Liquid water is warmer than solid ice, and the particles of water are looser than those of ice.

It is the same with steam. The particles of steam are not so closely packed as those of water.

Q. *How does this apply to iron struck with a hammer?*

A. The blow being confined to the iron, spends its force in loosening the particles thereof, and this change of state shows itself by increase of heat.

Q. *How used blacksmiths to* LIGHT *their* MATCHES, *before the general use of lucifers?*

A. They used to place a soft iron nail upon an anvil, and strike it a few times with a hammer, when the point of the nail became *sufficiently hot to light a brimstone match.*

Q. *Why does striking a* FLINT *against a piece of* STEEL *produce a* SPARK ?

A. Because the force employed in giving the blow, is changed from motion into heat.

Q. *How does this development of* HEAT *produce a* SPARK, *and set* TINDER *on fire?*

A. A very small fragment of the steel *is knocked off red-hot*, and sets fire to the tinder on which it falls.

Q. *Why is it needful to keep* BLOWING *the* TINDER *with the breath?*

A. To increase the supply of air, that the tinder may be furnished with more *oxygen* to assist combustion.

Q. *Where does the* OXYGEN *of the air* COME FROM, *which is blown to the lighted tinder?*

A. From the air itself, which is chiefly composed of two gases *(nitrogen and oxygen)* mixed together.

Five gallons of common air contain nearly 4 of nitrogen, and 1 of oxygen *mixed* together, but not chemically combined.

Q. *What is the* USE *of* OXYGEN GAS *to lighted tinder?*

A. It *supports the combustion* of the tinder. *Blowing* lighted tinder carries *oxygen* to it and *quickens* it, in the same way as a pair of bellows quickens a dull fire.

Q. *Why do* HORSES *sometimes* STRIKE FIRE *with their* FEET?

A. Because their iron shoes strike against the flint-stones of the road; and *very small fragments* are *knocked off red-hot*, and look like sparks.

Q. *What makes these fragments* RED-HOT?

A. The conversion of the force of the kick into heat, another *form* of force.

CHAPTER VIII.

2.—FRICTION.

Q. *What is meant by* FRICTION?

A. The act of *rubbing two things together;* as the Indians rub two pieces of *wood* together to produce fire.

Q. *How do the Indians produce* FIRE, *by merely rubbing* TWO PIECES *of dry* WOOD?

A. They take a piece of dry wood sharpened to a point, and rub this point up and down a *flat piece* very quickly, till a *groove* is made. In a few minutes, the *dust* (collected in this groove) *catches fire.*

Q. *Why does the wood-dust catch fire by rubbing?*

A. Because the force employed by rubbing is converted into heat, and the heat produced is sufficient to ignite such unsubstantial articles as wood-dust.

The best woods for this purpose are *boxwood* against *mulberry*, or *laurel* against *poplar* or *ivy.*

Q. *Why do* CARRIAGE WHEELS *sometimes catch fire?*

A. Either because they are too *dry*, or *fit too tightly*, or *revolve very rapidly.*

Q. *Why do wheels catch* FIRE *in such cases?*

A. Because the force intended to produce motion is obstructed in its duty, and part of it is converted into heat instead.

Q. *What is the use of* GREASING *wheels?*

A. It *lessens friction.* And as *less* force is required to overcome resistance, *more* of it is left to produce motion.

Q. *Why does* RUBBING *our* HANDS *and* FACES *make them feel warm?*

A. 1st.—Because the force employed in rubbing is converted into heat;

2ndly—Because part of the force is communicated to the blood, and helps to quicken its motion.

Q. *When a man has been almost* DROWNED, *why is animation restored by* RUBBING?

A. 1st.—Because the force employed in rubbing the body is converted into heat:

2ndly—Because part of the force is communicated to the *organs of the body*, and gives them the needful fillip to set them in action again.

Q. *Why do two pieces of* ICE *rubbed together* MELT ?

A. Because *force* is employed in *rubbing* the ice, and enough of the force is converted into heat to *melt* it.

Q. *How are* FORESTS *sometimes set on* FIRE *by friction?*

A. The branches of contiguous trees rub against each other, and the force of the friction is converted into heat.

Q. *Why do carpenters' tools (such as gimlets, saws, files, &c.) become* HOT *when used?*

A. Because *part* of the force employed is arrested by the resistance offered, and this part is converted from motion into heat.

Q. *Give an* ILLUSTRATION *of this.*

A. When cannon is bored, the borers become so intensely hot from friction, that, if *touched*, they would blister the hand which touched them.

Q. *Why do* BORERS *become so intensely hot?*

A. Because the resistance is very great, and much of the force intended for *piercing* is converted into heat.

3.—CONDENSATION *or* COMPRESSION.

N.B. The reduction of matter into a smaller compass by any *external* or *mechanical* force, is called COMPRESSION.

The reduction of matter into a smaller compass by some *internal* or *chemical* force, is called CONDENSATION.

Q. *What is meant by* COMPRESSION?

A. The act of *bringing parts nearer together;* as a sponge is *compressed* by being *squeezed* in the hand.

Q. *Can* HEAT *be evolved from common air merely by* COMPRESSION?

A. Yes. If a piece of *German tinder* is placed at the *bottom of a glass tube,* and the air in the tube is *compressed by a piston,* the tinder will catch fire.

In a common syringe or squirt, the *handle* part (which *contains the sucker*, and is forced up and down) is called "the piston."

Q. *Why will the tinder catch fire?*

A. Because the *force* employed in compressing the tinder, being suddenly arrested, is converted from motion into heat.

Q. *Why will small quantities of sulphur and chlorate of potash* DETONATE *when rubbed together in a mortar?*

A. Because the particles of the two substances are *compressed* so closely together, that their several *chemical affinities* are brought into action.

To "detonate" is to explode or burn with a sudden report.

Q. *Why do* DETONATING *salt and powder* EXPLODE, *on being rubbed or struck?*

A. Because *force* is employed in rubbing or striking, and enough of it is changed into *heat* to ignite such explosive things as detonating salt and powder.

Q. *Why are* SHOT *and* CANNON BALLS HEATED *by being discharged from a gun?*

A. Because they are compressed, and rubbed against the sides of the gun by the explosion of the powder.

CHAPTER IX.

EFFECTS OF HEAT.

1.—EXPANSION.

Q. *What are the principal* EFFECTS *of* HEAT

A. 1.—Expansion. 2.—Liquefaction. 3.—Vaporization, and 4.—Ignition.

Q. *Show that* HEAT EXPANDS AIR.

A. If a bladder (partially filled with air) be tied up at the neck, and *laia before a fire*, the air will expand till the bladder *bursts.*

Q. *Why will the* AIR SWELL, *if the bladder be laid before a fire?*

A. Because the heat of the fire will drive the particles of air *apart from each other*, and cause them to occupy more room than they did before.

Q. *Why do unslit* CHESTNUTS CRACK *with a loud noise, when* ROASTED?

A. Because they contain a great deal of air, which is expanded by the heat of the fire: and (not being able to escape *bursts* violently through the thick rind *slitting it*, and making a great noise.

Q. *What occasions the loud* CRACK *or report which we hear?*

A. 1st—The *sudden bursting of the rind* makes a report; in the same way as a piece of *wood* or *glass* would do, if *snapped in two;* and

2ndly—The *escape of hot air* from the chestnut makes a report also; in the same way as the escape of the gases formed by the explosion of gunpowder does.

Q. *Why does the sudden bursting of the rind, or snapping of a piece of wood, make a* REPORT?

A. Because a *violent jerk* is given to the air, when the attraction of cohesion is thus suddenly overcome: This jerk produces *rapid undulations* in the air, which (striking upon the ear) cause the sensation of *sound.*

Q. *Why does the escape of air from the chestnut, or the explosion of gunpowder, produce a* REPORT?

A. Because the sudden expansion of the imprisoned air. produces a partial vacuum: The *report* is caused by the rushing of *fresh air* to fill up this vacuum.

See Thunder, p. 8.

Q. *If a* CHESTNUT *be* SLIT, *it will* NOT *crack; why is this?*

A. Because the *heated air* of the chestnut can then *freely escape* through the *slit in the rind.*

Q. *Why does an* APPLE *split and spurt about, when roasted?*

A. In some measure from the *expansion* of *air by heat;* but more especially because its *juice* is converted into *steam.*

Q. *How is the* JUICE *of an* APPLE *confined in the fruit?*

A. By being placed in numerous *little cells* (like those of an honey-comb): When the *juice* is converted into *steam,* it bursts through these cells; and forces those parts which oppose it through the peel.

Q. *When an* APPLE *is* ROASTING, *why is one part made soft, while the rest remains hard?*

A. Because the *vegetable matter* of the part nearest the fire is cooked by the steam of the hot juices: and where the heated air and steam break through and escape, the apple *collapses* and becomes soft.

Q. *What is meant by the "apple* COLLAPSING*?"*

A. It means that the *plumpness* gives way, and the apple becomes *flabby* and *shrivelled.*

Q. *Why do* SPARKS *of fire start (with a crackling noise) from pieces of* WOOD *laid upon a* FIRE*?*

A. Because the *air* (expanded by heat) *forces its way* through the *pores of the wood*; and carries along with it the *covering* of the *pore*, which resisted its passage.

The conversion of the woody fibre of the interior parts into combustible gases, contributes to this effect.

Q. *What is meant by the "* PORES *of the* WOOD*?"*

A. Very small *holes in the wood,* through which the *sap* circulates.

Q. *What are the* SPARKS *of fire, which burst from the* WOOD*?*

A. Very small pieces of wood made *red-hot,* and separated from the log by the *force of the air,* when it bursts from its confinement.

Q. *Why does* DEAL *make more snapping than any other wood?*

A. Because the pores of deal are *very large*, and contain *more air* than those of wood having a *closer grain.*

Q. *Why does* GREEN *wood make less snapping than dry?*

A. Because the pores contain *less air*, being filled with *sap.*

Q. *Why does* DRY WOOD *make more snapping than green?*

A. Because the sap is *dried up*, and the pores are filled with *air* instead.

Q. *Why does* DRY *wood* BURN *more easily than green or wet wood?*

A. Because the pores of green or wet wood are filled with *moisture*, which extinguishes flame; whereas the pores of dry wood are filled with air, which supports combustion.

Q. *Why does* MOISTURE *extinguish flame?*

A. 1st—Because it prevents the *carbon* and *hydrogen* of the fuel from uniting with the *oxygen* of the air, to form *carbonic acid gas* and water: and

2ndly—Because heat is perpetually carried off, by the formation of the sap *into steam.*

Q. *Why do* STONES *snap and fly about, when heated in the fire?*

A. Because the close texture of the stone prevents the hot air from escaping; in consequence of which, it *bursts forth with great violence*, tearing the stone to atoms, and forcing fragments into the room.

Probably some part of this effect is due to the setting free of the *water of crystallization.*

Q. *When bottled ale or porter is set before a fire, why is the cork forced out sometimes?*

A. Because the *carbonic acid* of the liquor *expands* by the heat, and drives out the cork.

Carbonic acid gas is a compound of carbon and oxygen. All fermented liquors contain more or less of carbonic acid gas; bottled ale or porter a large quantity.

Q. *Why does ale or porter* FROTH *more, after it has been set before a fire?*

A. Because the heat of the fire sets free the *carbonic acid;* which is entangled as it rises through the liquor, and produces bubbles or froth.

Q. *When a boy makes a* BALLOON, *and sets fire to the cotton or sponge (which has been steeped in spirits of wine), why is the balloon* INFLATED?

A. Because the *air* of the balloon is *expanded by the flame*, till every part is inflated and the paper made smooth.

Q. *Why does the balloon* RISE, *after it has been inflated by the expanded air?*

A. Because the same quantity of air is expanded to *three or four times* its *original volume;* and made so much *lighter*, that even when all the paper, wire, and cotton are added, it is still lighter than common air.

The balloon ascends in consequence of the pressure from beneath of the heavier cold air by which it is surrounded, in the same way as the hot air in a chimney.

Q. *Why does a* SMOKE-JACK *turn round in a chimney?*

A. Because the *current* of *hot air* up the chimney (striking against the oblique vanes of the smoke-jack) drives them round: as wind drives round the sails of a mill.

Q. *Which* EXPAND *the most under the* SAME DEGREE *of heat—gases, liquids, or solids?*

A. Gases: all of which expand in the same ratio from heat.

Q. *What degree of expansion in gases is caused by heat?*

A. 481 degrees of heat will make a volume of gas twice as large as it was before.

Q. *What is the difference between a* VAPOUR *and a* GAS?

A. A VAPOUR is an elastic aeriform fluid, which may readily be converted into a liquid or solid merely by *change of temperature.*

A GAS is an elastic aeriform fluid, which cannot be made to change its state, except by the application of *artificial pressure* and *intense cold.*

Carbonic acid gas has even been converted into the solid form by the use of these means.

The vapour produced by the boiling of water is called *steam.*

Q. *What would gases be at* VERY LOW *temperatures?*

A. All gases would *probably* be *liquid* at *extremely low temperatures*; but the most *intense cold* hitherto artificially produced, has not been sufficient to reduce some of the gases to a liquid state.

Gases which cannot by our present means be brought into the liquid form, are called "*permanent,*" to distinguish them from vapours.

Q. *Why are some things* SOLID, *others* LIQUID, *and others* GASEOUS?

A. Because the particles which compose some things are nearer together than they are in others.—Those in which the particles are *closest* are *solid;* those in which they are *furthest apart* are *gaseous;* and the rest *liquid.*

Q. *Why does heat change a* SOLID (*like ice*) *first into a* LIQUID, *and then into a* GAS?

A. Because it drives the component particles further *asunder;* hence a certain quantity of heat changes solid ice into a *liquid,*—and a further addition of heat changes the liquid into *steam.*

Q. *Why does water* SIMMER *before it boils?*

A. Because the particles of water near the *bottom* of the kettle (being formed into steam *sooner* than the rest) *shoot upwards:* but are *condensed* again by *the colder surface of the water,* and produce what is called "simmering."

Q. *What is meant by* SIMMERING?

A. A gentle tremor or *undulation* on the surface of hot water. When water *simmers,* the bubbles *collapse beneath the* *surface*, and the steam is condensed to *water again;* but when water *boils*, the bubbles *rise through the surface*, and the *steam is thrown off*.

Q. *Why does a* KETTLE SING, *when the water simmers?*

A. Because the entangled air escapes by *fits* and *starts* from the surface of the water; producing the noise called "singing."

Q. *Why does* NOT *a kettle* SING, *when the water boils?*

A. Because *all* the water is *boiling hot;* so the steam escapes in large quantities from the entire surface, and not by *fits and starts.*

Q. *When does a kettle sing* MOST?

A. When it is set on a *hob* to boil.

Q. *Why does a kettle* SING MORE, *when it is set on the* SIDE *of a fire, than when it is set in the* MIDST *of a fire?*

A. Because the heat is applied *unequally*, and one side being made hotter than the other, the water takes longer time to boil.

Q. *Why does a* KETTLE *sing, when the boiling water begins to* COOL *again?*

A. Because the *upper* surface cools *first;* and the steam (which rises from the lower part of the kettle) is *again* partially condensed, and escapes by *fits* and *starts.*

Q. *Why does* BOILING *water increase in bulk?*

A. Because it is *expanded by the heat:* i.e.—The heat of the fire drives the particles of water *further apart* from each other: and (as they are not *packed so closely together*) they take up *more room.*

Q. *What is meant when it is said, "that* HEAT *drives the* PARTICLES *of water further* APART *from each other?"*

A. Water is composed of little globules, like very small grains of sand: the heat *drives* these particles apart from each other, and (as they then require more room) the water increases in bulk.

Q. *Why does boiling water* BUBBLE*?*

A. Because the heated air and *vapour* (rising through the water) force up bubbles in their effort to escape.

Q. *Why does a* KETTLE *sometimes* BOIL OVER?

A. Because the water is *expanded by heat:* if, therefore, a kettle is filled with *cold water*, some of it must *run over*, as soon as it is *expanded by heat.*

Q. *But I have seen a kettle* BOIL OVER, *although it has not been filled* FULL *of water; how do you account for this?*

A. If a *fire* be fierce, the air and vapour are expelled so *rapidly*, that the *bubbles are very numerous;* and since these carry portions of the water with them, some of it runs over.

Q. *Why is a pot (which was full to* OVERFLOWING, *while the water was boiling* HOT) NOT FULL, *after it has been taken off the fire for a short time?*

A. Because (while the water is *boiling*) it is expanded by the heat, and fills the pot even to overflowing; but, when it becomes cool, it *contracts* again, and occupies a less space.

The cooling of the water prevents any further escape of steam; and the generation of steam is one cause of the expansion of hot water.

Q. *Why does the water of a* KETTLE *sometimes run out of the* SPOUT *when it* BOILS?

A. Because when the lid fits tightly,

the steam cannot lift it up and escape; being confined, therefore, in the kettle, it *presses on the water* and forces it out of the spout.

Q. *What causes the* RATTLING NOISE, *often made by the lid of a saucepan or boiler?*

A. The steam (seeking to escape) *forces up the lid* of the boiler, and the *weight* of the lid carries it *back again*; this being done *frequently*, produces a rattling noise.

Q. *If the steam could* NOT LIFT UP *the lid of the boiler, how would it escape?*

A. If the lid fitted so tightly, that the steam could not raise it up, the boiler would *burst*, and the consequences might be serious.

Q. *When steam pours out from the spout of a kettle, the* STREAM *begins apparently* HALF AN INCH *off the* SPOUT; *why does it not begin* CLOSE *to the spout?*

A. Steam is really *invisible;* and the half-inch (between the spout and the "*stream of mist*") is the *real steam*, before it has been condensed by the air.

Q. *Why is not* ALL *the steam* INVISIBLE, *as well as that half-inch?*

A. Because the invisible particles are condensed by the *cold air;* and, rolling one into another, look like mist.

Q. *What* BECOMES *of the* STEAM, *for it soon vanishes?*

A. After it has been condensed into mist, it is *dissolved by the air* and dispersed abroad as *invisible vapour.*

Q. *And what* BECOMES *of the invisible vapour?*

A. Being *lighter* than air, it *ascends* to the upper regions of the atmosphere, where (being again *condensed*) it contributes to form *clouds.*

Every portion of the atmosphere contains more or less invisible vapour, varying from day to day with the state of the weather.

Q. *Why does a* METAL SPOON *(left in a saucepan)* RETARD *the process of boiling?*

A. Because the metal spoon (being an excellent *conductor*) *carries off the heat from the water;* and (as heat is carried off by the spoon) the water takes a longer time to boil.

Q. *Why will a pot (filled with water)* NEVER BOIL, *when immersed in another vessel full of water also?*

A Because water contained in an

open vessel can never be heated *above the boiling point;* all the heat absorbed by water after it *boils*, is employed in generating *steam.*

Q. *How does the conversion of water into steam, prevent the* INNER *pot from boiling?*

A. Directly the water in the larger pot is *boiling hot* (or 212°,) *steam is formed* and carries off *some of its heat;* therefore, 212 degs. of heat can never *pass through it*, to raise the *inner* vessel to *boiling heat.*

Q. *Why do* SUGAR, SALT, *&c.,* RETARD *the process of boiling?*

A. Because they increase the *density* of water; and whatever increases the *density* of a fluid retards its boiling.

Q. *If you want water to boil without coming in contact with a* SAUCEPAN, *what plan must be adopted?*

A. We must *immerse the pot* (containing the water to be boiled) in a saucepan containing *strong brine* or sugar.

Q. *Why would the* INNER *vessel boil if the* OUTER *vessel contained strong* BRINE?

A. Because *brine* will not boil, till it is raised to 218 or 220 *degs.* Therefore, 212 *degs.* of heat may easily pass through it, to *raise the vessel immersed in it to boiling heat.*

Q. *Why will brine impart to another vess* MORE *than* 212°, *and water* NOT SO MUCH?

A. Because no liquid can impart so high a degree of heat, as its own *boiling* temperature: As water boils at 212°, it cannot impart 212° of heat: but, as brine will not boil without 218° of heat, it can impart enough to make water boil.

Q. *Why can liquids impart no* EXTRA *heat, after they boil?*

A. Because all *extra* heat is spent in *making steam.* Hence water will not boil a vessel of *water* immersed in it, because it cannot impart to it 212 *degs.* of heat; but *brine* will, because it can impart *more* than 212 *degs.* of heat, before it is *itself* converted into steam.

Ether boils at about	96 *degs.*	Syrup boils at	221 *degs*
Alcohol	176 „	Oil of turpentine	316 „
Water	212 „	Sulphuric acid	472 „
Water, with one-fifth salt	219 „	Linseed oil	640 „
		Mercury	662 „

Any liquid which boils at a *lower* degree can be made to boil, if immersed in a liquid which boils at a *higher* degree. Thus a *cup of ether* can be made to boil in a saucepan of *water.* A *cup of water,* in a saucepan of *brine or syrup.* But a *cup of water* will not boil, if immersed in *ether;* nor a *cup of syrup,* in *water.*

Q. *Why are clouds* HIGHER *on a fine day?*

A. Because they are *lighter*, and *more buoyant.*

Q. *Why are clouds* LIGHTER *on a* FINE *day?*

A. 1st—Because the vapour of the clouds is *less condensed;* and

2ndly—The *air* itself (on a fine day) retains more of its vapour in an *invisible* form.

Q. *Why is a* CUP *put* INVERTED *into a fruit pie?*

A. Its principal use is to hold the *crust up* and prevent it from *sinking*, when the cooked fruit gives way under it.

Q. *Does not the cup* PREVENT *the fruit of the pie from* BOILING OVER?

A No; it will rather tend to *make* it boil over, as there will be *less room* in the dish.

Q. *Explain this.*

A. When a pie is put into an oven, the *air* in the cup will *begin* to *expand*, and drive every particle of juice from under it; in consequence of which, the pie-dish will have a cup-full *less room* to hold its fruit in, than if the cup were *taken out.*

Some of the heated air is driven from the cup, and escapes in bubbles through the juice, and out of the pie altogether. The place of this is occupied by juice when the pie cools.

Q. *If the juice is driven* OUT *of the cup, why is the* CUP *always* FULL *of juice, when the pie is cut up?*

A. Because immediately the pie is "*drawn*," the air in the cup begins to *contract again*, and occupy a *smaller space*. and as the cup is no longer full of *air*, *juice* rushes in to occupy the void.

Q. *Why does juice rush into the cup, when the cup is* NOT FULL *of* AIR?

A. Because the external air presses upon the *surface of the juice*, which rushes *unobstructed* into the cup: as mercury rises through the tube of a barometer.

N.B.—Since the juice of the pie runs into the cup, as soon as it is taken out of the oven, the cup prevents the juice from being *spilt over the crust*, when the pie is carried about from place to place, although it does not prevent the fruit from boiling over.

CHAPTER X.

EXPANSION FROM HEAT.

(*Continued.*)

Q. *Does heat expand every thing* ELSE, *besides air and water?*

A. Yes: *every* thing (that man is acquainted with) is expanded by heat.

Q. *Why does a* COOPER *heat his* HOOPS RED-HOT, *when he puts them on a tub?*

A. 1st—As iron *expands by heat*, the hoops will be *larger* when they are red-hot: in consequence of which, they will fit on the tub *more easily:* and

2ndly—As iron *contracts by cold*, the hoops will *shrink* as they cool down, and girt the tub with a *tighter grasp.*

Q. *Why does a* WHEELWRIGHT *make the iron hoop or "tire"* RED-HOT, *which he fixes on a* WHEEL?

A. 1st—That it may fit on more *easily;* and

2ndly—That it may girt the wheel *more tightly.*

Q. *Why will a wheelwright's* HOOP FIT *the wheel* MORE EASILY, *for being made* RED-HOT?

A. Because it will be *expanded* by the heat; and (being larger) will go on the wheel more *easily.*

Q. *Why will the* HOOPS, *which have been put on* HOT, GIRT *the wheel more* FIRMLY?

A. Because they will *shrink* as they cool; and, therefore, *girt the wheel* with a *tighter grasp.*

Q. *Why does a* STOVE *make a* CRACKLING NOISE, *when a fire is very hot?*

A. Because it expands from the heat; and the parts of the stove *rubbing* against each other, or driving against the *bricks*, produce a *crackling* noise.

Q. *Why does a stove make a similar* CRACKLING NOISE, *when a large fire is* TAKEN DOWN?

A. Because it *contracts again*, when the fire is removed; in consequence of which, the parts *rub against* each other again, and their connection with the bricks is *again disturbed.*

Q. *Why does the* PLASTER *round a stove* CRACK *and fall away?*

A. Because (when the fire is lighted) the *iron-work* expands more than the brick-work and plaster, and *pushes them away;* but (when the fire is put out) the metal *shrinks* again, and leaves the "setting" behind.

The "setting" is a technical word for the plaster, &c., in immediate contact with the stove.

Q. *Why does the plaster* FALL AWAY?

A. As a *chink* is left (between the "setting" and the stove), the plaster will frequently fall away from its own weight.

Q. *What* OTHER *cause contributes to* BRING *the* PLASTER DOWN?

A. As the *heat* of the fire varies, the *size* of the iron stove varies also; and this expanding and contracting keep up such a *constant disturbance* about the plaster, that it *cracks and falls off.*

Q. *Why does the* MERCURY *of a* THERMOMETER RISE *in hot weather?*

A. Because heat *expands the metal,* which (being increased in bulk) occupies a *larger space;* and, consequently, rises higher in the tube.

Q. *Why is a* GLASS BROKEN, *when* HOT WATER *is poured into it?*

A. Because the *inside* of the glass is suddenly more expanded by the hot water than the *outside;* and in consequence of this unequal expansion the *glass snaps*

Q. *Why is not the* OUTSIDE *of the glass expanded by hot water, as much as the* INSIDE *?*

A. Because glass is a bad conductor of heat, and *breaks* before the heat of the *inner* surface is conducted to the *outside.*

Q. *Why does a glass snap, because the* INNER *surface is* HOTTER *than the* OUTER *?*

A. Because the *inner* surface is expanded, and not the *outer:* in consequence of which, an *opposing force* is created which breaks the glass.

Q. *Why is a* CHINA CUP *broken, if* HOT WATER *be poured over it, or into it?*

A. Because china is a bad conductor; and (as the *inner* surface expands from the heat more than the *outer,*) an *opposing force* is created, which breaks the cup.

Q. *If a glass beaker be set on a warm* HOB, *why does the* BOTTOM COME OFF?

A. Because glass is a bad conductor; and (as the *bottom* of the glass expands from the warmth of the hot stove, before the *sides* are heated) the two parts *separate* from each other

CHAPTER XI

2.—LIQUEFACTION.
3.—VAPORIZATION.

Q. *What is meant by* LIQUEFACTION?

A The conversion of a *solid* into a *liquid* by the agency of heat: as solid ice is converted into water by the heat of the sun.

Q. *Why is ice* MELTED *by the* HEAT *of the* SUN?

A. Because the heat of the sun *forces its particles asunder;* till their attraction of cohesion is sufficiently overcome, to *convert the solid ice into a liquid.*

See p. 115.

Q *Why are* METALS MELTED *by the heat of* FIRE?

A. Because the heat of the fire *forces their particles asunder;* till their attraction of cohesion is sufficiently overcome, to *convert the solid metal into a liquid.*

Q. *Why is* WATER *converted into* STEAM *by the heat of the* FIRE?

A. Because the heat of the fire

separates its globules into very *minute bubbles;* which (being lighter than air) fly off from the surface in the form of *steam.*

Q. *Why does not* WOOD MELT *like metal?*

A. Because the heat of the fire *decomposes* the wood into *gas*, *smoke*, and *ashes;* and the different parts *separate* from each other.

Q. *What is meant by* VAPORIZATION?

A. The *conversion* of a *solid or liquid* into *vapour:* as snow or water is converted into vapour by the heat of the sun.

Q. *What are* CLOUDS?

A. Moisture *evaporated* from the *earth*, and again partially *condensed* in the upper regions of the air.

Q. *What is the difference between a* FOG *and a* CLOUD?

A. Clouds and fogs differ only in one respect. *Clouds* are *elevated above our heads:* but *fogs come in contact with the surface of the earth.*

Q. *Why do clouds* FLOAT *so readily in the air?*

A. Because they are composed of

very minute globules (called vesicles); which (being lighter than air) float, like *soap bubbles.*

Q. *Why does* VAPOUR *sometimes form into* CLOUDS, *and sometimes rest upon the earth as* MIST *or* FOG?

A. This depends on the *temperature* of the air. When the *surface* of *the earth* is *warmer than the lower air*, the vapour of the earth (being condensed by the chill air) becomes *mist or fog*. But, when the *lower air* is *warmer than the earth*, the vapour *rises through the air*, and becomes cloud.

Q. *Are* ALL *clouds* ALIKE?

A. No. They vary greatly in *density*, *height*, and *colour*.

Q. *What is the* CHIEF *cause of fog and clouds?*

A. The changes of the wind.

Many *local* circumstances also favour the formation of clouds.

Q. *How can the* CHANGES *of the* WIND *affect the* CLOUDS?

A. If a *cold current of wind blows* suddenly over any region, it *condenses* the invisible vapour of the air into *cloud* or *rain:* but if a *warm current of wind* blows over any region, it *disperses* the clouds, by *absorbing the vapour*.

Q. *What countries are the* MOST *cloudy?*
A. Those where the winds are *most variable*, as Britain.

Q. *What countries are the* LEAST *cloudy?*
A. Those where the winds are *least variable*, as Egypt.

Q. *What* DISTANCE *are the* CLOUDS *from the* EARTH?
A. Some *thin light clouds* are elevated above the highest mountain top; some *heavy* ones touch the steeples, trees, and even the earth: but the *average* height is between *one and two miles*.

N.B.—Streaky curling clouds *like hair*, are often 5 or 6 miles high.

Q. WHAT *clouds are the* LOWEST?
A. Those which are *most highly electrified:* lightning clouds are rarely more than about 700 yards above the ground; and often actually *touch the earth with one of their edges*.

Q. *What is the* SIZE *of the* CLOUDS?
A. Some clouds are 20 *square miles in surface*, and above *a mile in thickness;*

while others are only a *few yards* or *inches.*

Q. *How can persons ascertain the* THICKNESS *of a cloud?*

A. As the *tops* of high mountains are generally above the clouds, travellers may pass quite through them into a clear blue firmament; when the clouds will be seen *beneath their feet.*

Q. *What produces the great* VARIETY *in the* SHAPE *of the clouds?*

A. Three things: 1st—The cause and manner of their *formation:*

2ndly—Their *electrical* condition: and

3rdly—Their relations to *currents of wind.*

Q. *How can* ELECTRICITY *affect the* SHAPE *of clouds?*

A. If one cloud be *full of electricity* and another *not*, they will be *attracted* to each other, and either coalesce,—diminish in size,—or vanish altogether

Q. WHAT *clouds assume the most* FANTASTIC *shapes?*

A. Those that are the most *highly electrified.*

Q. *What effect have* WINDS *on the* SHAPE *of clouds?*

A. They sometimes *absorb them entirely:* sometimes *increase their volume and density;* and sometimes *change the position of their parts.*

Q. *How can winds* ABSORB *clouds altogether?*

A. *Warm dry winds* will convert the substance of clouds into *invisible vapour,* which they will carry away in their own current.

Q. *How can winds* INCREASE *the bulk and density of clouds?*

A. *Cold* currents of wind will condense the *invisible vapour* of the air, and *add it to the clouds* with which they come in contact.

Q. *How can winds* CHANGE *the* SHAPE *of clouds, by altering the position of their parts?*

A. Clouds are so voluble and light, that every breath of wind changes the position of their ves'cicles or bubbles.

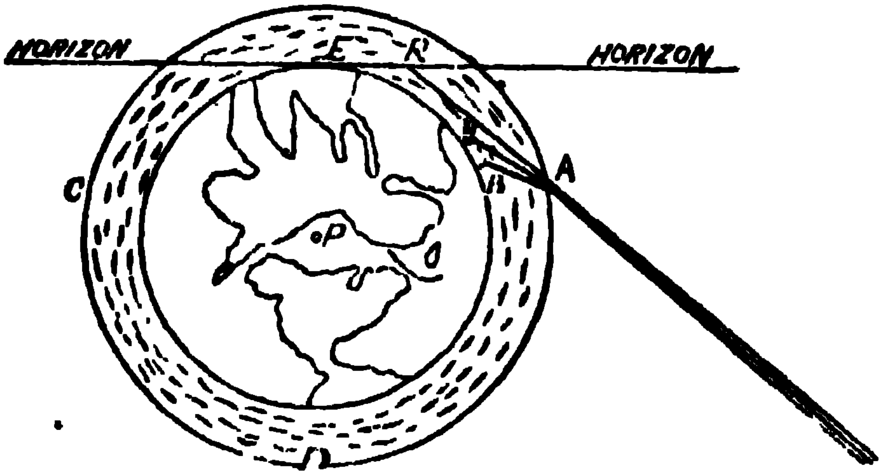
Q. *What are the general* COLOURS *of the clouds?*

A. White and grey; when the sun is *above the horizon:* but red, orange, and yellow, at *sun-rise* and sun-set.

The *blue sky* is not *cloud* at all.

Q. *Why are the* LAST *clouds of evening generally of a* RED *tinge?*

A. Because the *red* rays, being less *refrangible* than the *yellow* or *blue* rays, remain longest in sight, as the surface of the earth turns away from the sun.



Every beam of light is composed of three coloured rays, blue, yellow, and red. As the beam passes through the atmosphere A, these are separated from each other; the blue being drawn most down, the yellow next, and the red least. As the earth with its clouds and atmosphere turn round the pole P, in the direction A C D, any given cloud would pass first under the blue rays at B, then the yellow rays at Y, and then the red rays at R; and be tinged by their respective colours. An observer placed at E, just as he was turning into darkness towards C, would see the clouds tinged red at R, resting upon the western horizon.

Q. *Why are the* EARLY *morning clouds generally* RED?

A. Because the *red* rays, being less *refrangible* than the *yellow* or *blue* rays, come soonest into sight, as the surface of the earth turns into daylight.

Suppose the earth to be turning in the direction DCA. Then any given cloud would come first into the light of the red rays R, and the observer at E would see it so tinged on the eastern horizon, just as he was coming into daylight.

Q. *What is the cause of* MORNING TWILIGHT?

A. Some of the rays of *light* which strike the top of the atmosphere, are bent down while the sun is still *invisible* beneath the horizon.

Q. *What is the cause of* EVENING TWILIGHT?

A. Some of the *rays of light* which strike the top of the *atmosphere*, are bent down, when the sun has sunk out of sight beneath the horizon.

Q. *Why is not the colour of clouds always* ALIKE?

A. Because the *condition* of the *atmosphere* is continually *varying*, as also the *size*, *density*, and relative *position* of the clouds with regard to the sun: so that sometimes *one* colour is reflected, and sometimes *another*.

Q. *What regulates the* MOTION *of the clouds?*

A. Principally the *winds;* but sometimes *electricity* will influence their motion also.

Q. *How do you know that clouds move by* OTHER *influences besides* WIND?

A. Because (in calm weather), we often see *small clouds meeting each other* from opposite directions.

Q. *How do you know that* ELECTRICITY *affects the motions of the clouds?*

A. Because clouds often meet from *opposite directions;* and, having discharged their opposite electricities into each other, *vanish altogether.*

Q. *Into how many* CLASSES *are the different sorts of clouds generally divided?*

A. Into three classes:—viz. Simple, Intermediate, and Compound.

Q. *How are* SIMPLE *clouds sub-divided?*

A. Into 1.—Cirrus; 2.—Cum'ulus; and 3.—Stra'tus clouds.

Q. *What sort of clouds are called* CIRRUS?

A. Clouds like *fibres, loose hair,* or *thin streaks,* are called "cirrus clouds."

Q. *Why are these clouds called* CIRRUS?

A. From the Latin word *cirrus* ("a lock of hair, or curl"): Cirrus clouds are the *most elevated of all.*

Q. *What do* CIRRUS *clouds* PORTEND?

A. Fine weather. Whenever *cirrus clouds* appear, there is but little moisture in the air, and this is only slowly condensed in the higher regions of the atmosphere.

Q. *What sort of clouds are called* CUM'ULUS?

A. Cum'ulus cloud are lumps, like great *sugar loaves,—volumes of smoke,*— or *mountains towering over mountains.*

Q. *Why are these monster masses called* CUM'ULUS *clouds?*

A. From the Latin word *cum'ulus* (" a mass or pile.")

Q. *What do* CUM'ULUS *clouds* FORESHOW?

A. When these piles of cloud are *fleecy*, and sail *against the wind*, they indicate *rain;* but when their outline is very *hard*, and they come up *with* the wind, they foretell *fine weather.*

Cum'ulus clouds should be *smaller* towards evening than they are at noon. If they increase in size at sun-set, a thunder storm may be expected in the night.

Q. *What sort of clouds are called* STRA'TUS?

A. *Creeping mists*, especially prevalent in a summer's evening: these clouds rise at sun-set in *low damp places;* and are always *nearer the earth*, than any *other* sort of cloud.

Q. *Why are these mists called* STRATUS *clouds?*

A. From the Latin word *stra'tus* ("laid low," or "that which lies low.")

Q. *What produce* CIRRUS *clouds?*

A. Moisture in a visible form, deposited in the *higher regions* of the atmosphere from *ascending currents* of *heated air.*

Q. *What produce* CUMULUS *clouds?*

A. Masses of visible vapour passing from the places where they were *formed*, to other places where they are about to be either *dissolved*, or deposited as falling *rain.*

Q. *What produce* STRATUS *clouds?*

A. Beds of visible moisture, formed by some chilling effects, acting along the *direct surface* of the *earth.*

Q. *How are the* INTERMEDIATE *clouds subdivided?*

A. Into two sorts. 1.—The Cirro-Cumulus; and 2.—The Cirro-Stratus.

Q. *What are* CIRRO-CUMULUS *clouds?*

A. Cirro-Cum'ulus clouds are cirrus clouds springing from a *massy centre;* or *heavy masses*, edged with *long streaks*, generally called "mares' tails."

A system of *small round* clouds may be called cirro-cum'ulus.

Q. *What do* CIRRO-CUM'ULUS *clouds generally* FOREBODE?

A. Continued drought, or hot dry weather.

Q. *What are* CIRRO-STRA'TUS *clouds?*

A. They compose what is generally called a "*mackarel sky.*" This class of clouds invariably indicates *rain* and *wind;* hence the proverb—

"Mackarels' scales and mares' tails
Make lofty ships to carry low sails."

Q. *What produce* CIRRO-CUM'ULUS *clouds?*

A. *Cum'ulus* clouds dissolving away into *cirrus* produce the intermediate class, called CIRRO-CUM'ULUS.

Q. *What produce* CIRRO-STRA'TUS *clouds?*

A. *Cirrus* clouds accumulating into *denser* masses produce the intermediate class, called CIRRO-STRATUS.

Q. *How are* COMPOUND *clouds sub-divided?*

A. Compound clouds are sub-divided into 2 sorts. 1.—The Cum'ulo-Stra'tus; and 2.—The Nimbus clouds.

Q. *What is meant by* CUM'ULO-STRATUS *clouds?*

A. Those clouds, which assume all sorts of *gigantic forms;* such as vast towers and rocks,—huge whales and dragons,—scenes of battles,—and cloudy giants. This class of clouds is the most romantic and strange of all.

Q. *What do the* CUMULO-STRATUS *clouds* FORETELL?

A. A *change of weather;* either from fine to rain, or from rain to fine.

Q. *What are* NIMBUS *clouds?*

A. All clouds from which *rain falls.* Nimbus is the Latin word for "*clouds which bring a storm.*"

Q. *By what particular character may the* NIMBUS *(or rain-cloud) be at once distinguished?*

A. By the want of a *defined outline:* Its edge is gradually shaded off from the *deep grey mass* into *transparency.*

Q. *What* APPEARANCE *takes place in the clouds at the approach of* RAIN?

A. The *cum'ulus* cloud becomes *stationary*, and *cirrus streaks settle upon it*, forming cum'ulo-stra'tus clouds; *black* at first, but afterwards of a *grey* colour.

Q. *Why do clouds gather round* MOUNTAIN TOPS?

A. Because the air (being *chilled* by the cold mountain tops) deposits its vapour there, in a *visible form* or cloud.

Q. *What are the* USES *of* CLOUDS?

A. 1st—They act as *screens*, to arrest the radiation of heat from the earth;

2ndly—They temper the heat of the *sun's rays*; and

3rdly—They are the great *store-houses of rain.*

"Radiation of heat," i.e. the escape of heat, when no *conductor* carries it away.

Q. *Why is wind said to* BLOW UP *the clouds?*

A. Because a *dry warm* wind (which has travelled over seas) having absorbed a large quantity of moisture, deposits some of it in the *visible form of clouds*, as soon as it reaches a *colder* region of air.

Q. *Why does* WIND *sometimes* DRIVE AWAY *the clouds?*

A. Because it has travelled over *dry climes* or *thirsty deserts*, and become so *dry*, that it absorbs vapour from the clouds, and causes them to disappear.

Q. *What is the cause of a* RED *sunset?*

A. The vapour of the air not being *actually condensed into clouds*, but only on the *point of being condensed.*

Q. *Why is a* RED *sunset an indication of a* FINE DAY *to-morrow?*

A. Because the vapours of the earth are *not condensed into clouds*, even by the cold of sunset. Our Lord referred to this prognostic in the following words: "When it is evening ye say it will be fair weather, for the sky is red." (Matt. xvi. 2.)

Q. *What is the cause of a coppery* YELLOW SUN-SET?

A. The vapour of the air being *actually condensed into clouds.*

Q. *Why do vapours* (NOT *actually condensed*) *refract* RED *rays, while condensed vapour refracts yellow?*

A. Because the beams of light meet with very little resistance; in consequence of which, those rays are bent down to the eye, which require the least refraction, such as *red.*

See figure on p. 135, where it is evident that the red ray A R, is less bent, than the yellow and blue rays, A Y, A B.

Q. *Why do* CONDENSED *vapours refract* YELLOW *rays, whereas vapours not actually condensed refract red?*

A. Because the beams of light meet with *more resistance* from the condensed vapour; in consequence of which, those rays are bent down to the eye, which are *more refracted* than the red, such as yellow.

See figure on p. 135, where it is evident that the yellow ray A Y, is more bent than the red ray, A R.

Q. *Why is a* YELLOW SUN-SET *an indication of* WET?

A. Because it shows that the vapours of the *air* are already *condensed into clouds;* rain, therefore, may be shortly expected.

Q. *What is the cause of a* RED SUN-RISE?

A. Vapour in the upper region of the air *just* on the *point of being condensed*

Q. *Why may a red and lowering sky at morning be an indication of approaching* RAIN?

A. Because the *density* of the air is due to an excess of vapour at the *point of condensation;* hence our Lord's observation, "In the morning ye say, it will be foul weather to-day, for the sky is red and lowering." (Matt. xvi. 3.)

Professor Forbes has seen a red light in the jet of steam issuing from the valve of a locomotive, where it is just becoming visible from condensation. Professor Griffiths states, that the red and lowering morning sky, which indicates foul weather, *probably* depends upon excess of vapour in the atmosphere: but as a general rule, dry air is less transparent than moist, and red rays have more power to pierce through a dense atmosphere: hence the sun is red at rising or setting, or in a fog.

Q. *Why is a grey sun-rise often indicative of a* FINE *day?*

A. Because at the instant of sun-rise the higher regions of the air are comparatively *free* from moisture, and feeble white light can pass through.

Grey is only white in a diluted state.

Q. *Why is a yellow tint in the sky indicative of the approach of* WET?

A. Because it shows that the air is *moist.* Moist air is more transparent than dry, and allows yellow rays, which have *less momentum* than red, to pass through as well.

Q. *What difference (in the state of the air) is required to make a* GREY *and* RED *sun-rise?*

A. In a *grey* sun-rise the air is sufficiently clear to allow the *three* coloured rays to pass with a feeble degree of intensity. In a *red* sun-rise, the air is so dense that it stops all but the red rays. Hence the proverb—

"Evening red and morning grey,
Will set the traveller on his way;
But evening grey and morning red,
Will bring down rain upon his head."

Q. *Why is the sky* BLUE?

A. Because the *weak* blue rays, which are reflected *upwards* from the earth, cannot get through the air, and are therefore sent *down* again.

It is, properly, the air which is blue. Hence the sky becomes of a deeper colour, as we ascend high mountains.

Q. *The proverb says, "A rainbow in the* MORNING *is the shepherd's warning:" Why is it so?*

A. Because a *morning* rainbow must be always in the *west;* and indicates that bad weather is on the road to us.

Q. *Why must a* MORNING *rainbow be always in the* WEST?

A. Because the sun is in the *east;*

and a rainbow can be formed only when the rainy clouds are *opposite* to the sun.

Q. *Why does a rainbow in the* WEST *indicate that* BAD WEATHER *is on the road to us?*

A. Because our heavy rains are usually *brought by west or south-west winds;* and clouds which reflect the colour of the rainbow *in the west,* must be coming up *with the wind.*

This will not be true if the wind be easterly.

Q. *The proverb says, "A* RAINBOW *at* NIGHT *is the shepherd's delight:" Why is it so?*

A. Because a rainbow at *night* is in the *east;* and indicates, that bad weather is *leaving* us.

Q. *Why must a rainbow at* NIGHT *be always in the* EAST?

A. Because the sun is in the *west;* and a rainbow can be formed only when the rainy clouds are *opposite* to the sun.

Q. *Why does a rainbow in the* EAST *indicate that bad weather is* LEAVING *us?*

A. Because our rain is generally brought by *west* and *south-west* winds; when, therefore, the clouds (which reflect the rainbow) have been driven from the *west* to the *east*, is a plain proof that they have already passed over us, and are going away.

This will not be true if the wind be easterly.

Q *What is meant by an* AURORA BOREA'LIS, *or northern light?*

A. A *luminous* appearance in the *north* of the sky at night-time. Sometimes streaks of blue, purple, green, red, &c., and sometimes flashes of light are seen.

As these streams of light have a tremulous motion, they are called in the Shetland Isles, "Merry dancers."

Q. *Describe the appearance of the Aurora Borealis, visible in England on the night of November 17th,* 1848.

A. The sky overhead seemed in flames, and bands of various colours rose from the horizon to the North Star, forming a luminous arch. This magnificent appearance lasted from 7 till 10 o'clock at night.

Q. *Is this the usual appearance of the Aurora Borealis in our island?*

A. No. It is generally a luminous white band on the top of a pitchy dark cloud,—low down in the horizon,—and running from east to west of the due north.

Q. *What is the cause of the* AURORA BOREA'LIS, *or northern light?*

A. The passage of *electricity* through the higher regions of the atmosphere.

Q. *Why are there* DIFFERENT COLOURS *in the Aurora Borealis, such as white, yellow, red, and purple?*

A. Because the electric fluid passes through air of *different densities.* The most *rarefied air* produces a *white* light; the most *dry air, red;* and the most *damp* produces *yellow streaks.*

Q. *Is the Aurora Borealis ever accompanied by sound?*

A. Yes, it is frequently accompanied by sounds resembling hissing, murmuring, rumbling, or crackling.

When its coruscations are very bright, unsettled weather generally follows; but in 1848 and 1849, brilliant displays of the Aurora Borea'lis were followed by very fine weather.

Q. *Why does a* HAZE *round the* SUN *indicate* RAIN?

A. Because the *haze* is caused by *very fine rain, suspended in the upper regions of* *the air*; when this is the case, a *rain* of 5 or 6 *hours' duration* may be expected.

Q. *Why is a* HALO *round the* MOON *a sure indication of* RAIN?

A. Because it is caused by *fine rain*, suspended in the *upper regions* of the air. The *larger* the halo, the *nearer the rain-clouds*, and the sooner may rain be expected.

Q. *What is the cause of a* BLACK MIST: *and why does it bring* WET *weather?*

A. The mist is *black*, because it is *overshadowed by dense clouds*; and *wet* weather may be expected, because the air is saturated with vapour.

Q. *Why is* MIST *sometimes* WHITE: *and why does a white mist indicate* FINE *weather?*

A. The mist is *white*, because *no clouds blacken it with their shadow*; and *fine weather* may be expected, because the sky is cloudless.

Q *Why do we feel almost* SUFFOCATED *in a hot cloudy night?*

A. Because the heat of the earth cannot escape into the upper region of the air; but is pent-in by the clouds, and confined to the *surface of the earth.*

Q. *Why do we feel* SPRIGHTLY *in a clear bright night?*

A. Because the heat of the earth can readily escape into the upper regions of the air, and is not confined or pent-in by *thick clouds.*

Q. *Why do we feel* DEPRESSED *in* SPIRITS *on a* WET *murky* DAY?

A. 1st—Because the air is laden with vapour, and has (proportionally) *less oxygen.*

2ndly—The air being lighter than usual, *does not balance the air in our body:* and

3rdly—Moist air has a tendency to *depress the nervous system.*

Q. *What is meant by the "air balancing the air in our body?"*

A. The human body contains air of a given density; if, therefore, we ascend into *rarer air*, or descend into *denser*, the balance is destroyed, and *we feel oppressed.*

Q. *Why do we feel* UNCOMFORTABLE, *if the air around is not of the* SAME DENSITY, *as that in our body?*

A. Because if the air be *more* dense than our body, it will produce a feeling of *oppression;* if it be *less* dense, the air in our body will produce a feeling of *distension.*

Q. *Why do persons, who* ASCEND *in* BALLOONS, *feel* PAIN *in their eyes, ears, and chest?*

A. Because the air in the upper regions of the atmosphere is more *rare* than the *air in their bodies;* and (till *equilibrium is restored*) pain will be felt in the more sensitive parts of the body.

More especially in the tympanum of the ear.

Q. *Why do persons, who* DESCEND *in* DIVING-BELLS, *feel* PAIN *in their eyes, ears, and chest?*

A. Because the air in the diving-bell is *compressed* by the upward pressure of the water: in consequence of which, great pain is felt in the more sensitive parts of the body.

The pressure thus caused is sometimes sufficient to *rupture* the membrane of the tympanum, and produce incurable *deafness.*

Q. *Why are* PEARL DIVERS *very frequently* DEAF?

A. Because the *pressure of the water against* the tympanum of their ears *ruptures* the membrane; and this rupture produces incurable deafness.

Q. *When the white cloud from the chimney of a steam engine is seen trailing a long distance, why may* RAIN *be expected?*

A. Because the air is unwilling to absorb any more moisture, and must be already nearly saturated with it.

Q *At what* HOUR *of the day may this prognostic of rain be most certainly depended on?*

A. When it is seen at about three in the afternoon, a wet evening is almost sure to follow.

Q. *Which is the more dense,* MOIST *or* DRY *air?*

A. *Dry* air is the densest. The weight of the atmosphere almost always *diminishes* as the fall of *rain* approaches.

Q. *When are sounds* LOUDEST, *in* MOIST *or in* DRY *weather?*

A. All sounds are loudest in *dry* air, because it is *densest.*

The sound of a bell can be scarcely heard, when it is rung in the receiver of an air pump. And the report of a pistol is scarcely audible on the top of a high mountain.

Q. *Why do we feel* BRACED *and* LIGHT-HEARTED *on a* FINE *spring or* FROSTY *morning?*

A. 1st—Because there is *more oxygen* in the air on a fine frosty morning, than on a wet day: and

2ndly—A brisk frosty air has a tendency to *brace* the powers of the nervous system.

Q. *Why do dogs and cats (confined to a room) feel* LAZY *and* DROWSY, *at the approach of rain?*

A. 1st—Because the air does not contain *its full proportion of oxygen:* and

2ndly—The damp *depresses the powers of their nervous system*, and makes them drowsy.

Q. *When* SHEEP *lie under a* HEDGE, *and seem unwilling to go to pasture,* RAIN *is at hand. Explain the reason of this.*

A. The damp air *relaxes their nervous system*, and they consequently feel listless and drowsy.

Q. *Why do* HORSES *neigh,* CATTLE *low,* SHEEP *bleat, and* ASSES *bray, at the approach of rain?*

A. Damp air *relaxes their nerves*, and, therefore, they feel languid and uneasy.

Q. *Mention some* OTHER *animals, which indicate the approach of rain in a similar way.*

A. When pigs squeak, as if in great pain—frogs croak with a loud hoarse noise—owls screech—woodpeckers cry—peacocks scream—guinea-fowls squall—or ducks and geese are unusually noisy, rain is close at hand.

Q. *Why do* CANDLES *and* FIRES *burn with a* BLUER *flame in wet weather?*

A. Because the heat of fire is *less intense:* In consequence of which, some of the carbon is *not heated to whiteness.*

Unless the carbon be *intensely* heated, it will not unite with the oxygen to form carbonic acid, but will fly off as *smoke.*

Q *Why do* HILLS, *&c., appear* LARGER *in* WET *weather?*

A. Because the air is *laden with vapour*, which causes the rays of light to *diverge more;* in consequence of which, they produce on the eye *larger images of objects.*

Q. *Why do* TREES, *&c., in wet weather appear* FURTHER *off than they really are?*

A. Because the fog or mist *diminishes the light* reflected from the object; and as the object becomes *more dim,* it seems to be *further off.*

Q *Why do* OBJECTS *sometimes seem to* DANCE *in warm weather, after much rain?*

A. Because the *heat* makes the fallen rain *evaporate* again into the air very quickly, and the *ascending vapour* causes the density of the air near the ground to *vary* continually, and as the passage of the rays of light is affected, a twinkling or dancing motion is produced on the eye

Q *Do not* DOMESTIC ANIMALS *give some indications by which the approach of wet weather may be known?*

A. It is believed that *cats* and *house dogs* feel a cutaneous irritation at the approach of rain, and offer sensible evidence of uneasiness.

Virgil and Thompson have made the subject a theme for poetry. But the imagination which makes a good poet, does not always make an accurate teacher of scientific facts.

Q. *Why is the air generally* DRIER *before noon and before summer, than it is after noon and after summer?*

A. Because in the morning and in the spring, the heat of the air is on the increase, and is more capable of holding vapour suspended. In the afternoon and in the autumn it is getting on the decrease, and is less able to hold vapour suspended.

Q. *When the plants called* TREFOIL, DANDELION, PIMPERNEL, *&c.*, FOLD *up their leaves*, RAIN *is always close at hand: Explain this.*

A. 1st—The cloudy weather diminishes the *light of the sun;* and without the stimulus of sunlight, these flowers never open their leaves: and

2ndly—The vapour of the damp air, insinuates itself into the vessels of these delicate plants, and affects their vital sensibilities in some unknown way.

All these plants close at sun-set also.

Q. *Why do doors* SWELL *in* RAINY WEATHER?

A. Because the *air is filled with vapour*, which penetrates into the pores of the wood,—*forces the parts further apart*,—and swells the door.

Q. *Why do doors* SHRINK *in* DRY *weather?*

A. Because *moisture is absorbed from the wood:* and, as the particles are brought *closer together*, the size of the door is *lessened*,—in other words, the *door shrinks.*

Q. *Why is the air filled with offensive* SMELLS, *just previous to* RAIN?

A. Because the volatile parts which

rise from dunghills, sewers, &c., are arrested by the *vapour of the air*, and prevented from *rising* so readily, as when the sun is shining brightly.

Q. *Why do* FLOWERS *smell* SWEETER *and* STRONGER, *just previous to rain?*

A. Because the volatile parts which constitute the *perfume* of flowers, are prevented (by the vapour of the air) from *rising;* in consequence of which, they are confined to the lower regions of the atmosphere.

N.B.—Many essential oils and other volatile substances, which produce odours in plants, require the presence of *much moisture* for their perfect development.

Q. *Why do* HORSES *and other animals stretch out their necks, and* SNUFF *up the* AIR, *just previous to a fall of* RAIN?

A. Because they smell the *odour of plants and hay*, and delight to snuff in their fragrance.

Q. *Why does* SMOKE *fall, when* RAIN *is at hand?*

A. Because the air is *less dense*, and *cannot buoy up the smoke* so readily, as *dry and heavy air.*

Q. *Why do* SWALLOWS FLY LOW, *when* RAIN *is at hand?*

A. Because the *insects* (of which they are in pursuit) *have fled from the cold upper regions of the air*, to the *warm* air near the earth: and as their *food is low*, the swallows *fly low.*

Q. *Why do these* INSECTS *seek the lower regions of the air in* WET *weather, more than in* FINE?

A. Because (in wet weather) the *upper* regions of the air are *colder* than the *lower;* and, as insects enjoy warmth, they seek it near the earth.

Q. *Why does a* DOWNWARD *current of* COLD AIR *bring* RAIN?

A. Because it *condenses the warm vapour;* which (being condensed) descends in rain.

Hence rain generally follows a London "pea-soup" fog.

Q. *The proverb says,* "A SINGLE MAGPIE *in spring,* FOUL WEATHER *will bring:*" *Why is this the case?*

A. Because in cold stormy weather, *one magpie alone* will leave its warm snug nest *in search of food*, while the other stays with the *eggs, or young ones;* but in *fine mild* weather (when their brood will not be injured by cold) *both the magpies fly out together.*

Q. *Why is it* UNLUCKY *for* ANGLERS *to see a* SINGLE *magpie in spring?*

A. Because, when *magpies fly abroad singly,* the weather is cold and stormy; but, when *both birds fly out together*, the weather is *warm and mild*, which is *favourable for fishing.*

Q. *Why do* SEA-GULLS *fly about the* SEA *in* FINE *weather?*

A. Because they *live upon the fishes* which are found *near the surface* of the sea in fine weather.

Q. *Why may we expect* STORMY RAINS, *when* SEA-GULLS *assemble on the land?*

A. Because the fishes (on which they live) leave the *surface* of the sea in stormy weather, and are beyond the reach of the *sea-gulls:* so they are obliged to feed on the *worms and larvæ*, which come out of the *ground* at such times.

"Larvæ," little grubs and caterpillars.

Q. *Why do* PETRELS *fly to the* SEA, *during a storm?*

A. Because they *live upon insects*, which are always to be found in abundance *about the spray of swelling waves.*

N.B. Petrels are birds of the duck kind, which live in the open sea. They run on the top of the waves, and are called Petrels, from Petrello, an Italian word, which means *Little Peter*, in allusion to St. Peter's walking on the sea to go to Jesus. Our seamen call them Mother Carey's Chickens. Their presence at sea presages a storm.

Q. *Why do* CANDLES *and* LAMPS SPIRT, *when* RAIN *is at hand?*

A. Because the *air is filled with vapour* which *penetrates the wick;* where (being formed into *steam*) it expands suddenly, and produces a little explosion.

Q. *Why does a* DROP *of* WATER *sometimes* ROLL *along a piece of hot iron, without leaving the least trace?*

A. Because the *bottom* of the drop is turned into *vapour*, and *buoys the drop up*, without allowing it to touch the iron.

Q. *Why does it* ROLL?

A. Because the *current of air* (which is always passing over a heated surface) *drives it along.*

Q. *Why does a* LAUNDRESS *put a little* SALIVA *on a* FLAT-IRON, *to know if it be hot enough?*

A. Because, when the saliva *sticks* to the box, and is *evaporated*, she knows it is *not* sufficiently hot: but, when it *runs along the iron*, it is.

Q. *Why does the saliva* RUN *along the flat-iron when it is very* HOT?

A. Because the heat of the iron *converts the bottom of the drop into vapour;* when this is not the case, the saliva will *not roll* over the iron.

CHAPTER XII.

4.—EVAPORATION.

Q. *What is meant by* EVAPORATION?

A. The dissipation of liquid by its conversion into vapour.

Q. *What* EFFECTS *are produced by evaporation?*

A. The liquid vaporized *absorbs heat*

from the body whence it issues; and the body, *deprived of the liquid* by evaporation, *loses heat.*

Q. *If you* WET *your* FINGER *in your mouth, and hold it up in the air, why does it feel* COLD?

A. Because the saliva quickly *evaporates*; and (as it evaporates) *absorbs heat from the finger*, making it feel cold.

Q. *If you bathe your* TEMPLES *with ether, why does it allay* INFLAMMATION *and feverish heat?*

A. Because ether very rapidly *evaporates;* and (as it evaporates) *absorbs heat from the burning head*, producing a sensation of cold.

Q. *Why is* ETHER *better for this purpose than* WATER?

A. Because ether requires *less heat to convert it into vapour;* in consequence of which, it evaporates more *quickly.*

N.B.—Ether is converted into vapour with 96 degs. of heat: but water requires 212 degs. of heat to convert it into steam.

Q. *Why does* ETHER *very greatly* RELIEVE *a* SCALD *or* BURN?

A. Because it *evaporates very rapidly;* and (as it evaporates) *carries off the heat of the burn.*

Q. *Why do we feel* COLD, *when we have* WET FEET *or* CLOTHES?

A. Because the moisture of our shoes or clothes rapidly *evaporates;* and (as it evaporates) *absorbs heat from our body,* which makes us feel cold.

Q. *Why do* WET FEET *or* CLOTHES *give us* "COLD?"

A. Because the evaporation *absorbs heat* so abundantly from the surface of our body, that its temperature is *lowered below its natural standard;* in consequence of which, health is injured.

Q. *Why is it* DANGEROUS *to* SLEEP *in a* DAMP BED?

A. Because heat is continually absorbed from the surface of our body, to *convert the damp of the sheets into vapour:* in consequence of which, our animal heat is reduced *below the healthy standard.*

Q. *Why is* HEALTH INJURED, *when the temperature of the body is* REDUCED *below its natural standard?*

A. Because the *balance of the circulation* is destroyed: Blood is driven away from the *external surface* by the *chill,* and thrown upon the *internal organs*, which are *oppressed* by this increased *load of blood.*

Q. *Why do we not feel the same sensation of cold, if we throw a* MACINTOSH *over our* WET CLOTHES?

A. Because the macintosh (being air-tight) *prevents evaporation;* and (as the *wet cannot evaporate*) no heat is absorbed from our bodies.

Q. *Why do not sailors "catch* COLD," *who are frequently wet all day with* SEA-WATER?

A. 1st—Because the *salt* of the sea *retards evaporation;* and (as the heat of their body is drawn off *gradually*) the sensation of cold is prevented: and

2ndly—The *salt* of the sea acts as a stimulant, and keeps the blood circulating in the skin.

Q. *Why does* SPRINKLING *a* HOT ROOM *with water* COOL *it?*

A. Because the heat of the room causes a *rapid* evaporation of the sprinkled water: and as the water evaporates, *it absorbs heat from the room*, which cools it.

Q. *Why does* WATERING *the* STREETS *and roads* COOL *them?*

A. Because they part with their heat, to promote the *evaporation of the water* sprinkled on them.

Q. *Why does a* SHOWER *of* RAIN COOL *the* AIR *in summer-time?*

A. Because the wet earth *parts with its heat to promote evaporation;* and when the *earth* is cooled, it *cools the air* also.

Q. *Why is* LINEN DRIED *by being exposed to the* WIND?

A. Because the wind *accelerates evaporation*, by removing the vapour from the *surface of the wet linen*, as fast as it is formed.

Q. *Why is* LINEN DRIED *sooner in the open* AIR, *than in a confined room?*

A. Because the particles of vapour are more rapidly removed from the surface of the linen, which increases the evaporation.

Q. *Why are* WET *summers generally succeeded by* COLD *winters?*

A. Because the great evaporation (carried on through the wet summer) reduces the temperature of the earth *lower than usual*, and produces cold.

Q. *Why is England* WARMER *than it used to be, when* AGUES *were common?*

A. Because it is *better drained*, and *better cultivated.*

Q. *Why does* DRAINING *land promote* WARMTH?

A. Because it *diminishes evaporation;* in consequence of which, *less heat* is abstracted from the earth.

Q. *Why does cultivation increase the* WARMTH *of a country?*

A. 1st—Because *hedges* and *belts of trees* are multiplied:

2ndly—The land is *better drained;* and

3rdly—The vast *forests are cut down.*

Q. *Why do* HEDGES *and* BELTS *of* TREES *promote* WARMTH?

A. Because they *retard evaporation*, by keeping off the *wind.*

Q. *If belts of trees promote* WARMTH, *why do forests produce* COLD?

A. 1st—Because they *detain* and *condense the passing clouds.:*

2ndly—They prevent the access of both *wind* and *sun:*

3rdly—The soil of forests is always

covered with long damp grass, rotting leaves, and *thick brushwood:* and

4thly—In every forest there are always many hollows *full of stagnant water.*

Q. *Why do* LONG GRASS *and* ROTTING LEAVES *promote* COLD?

A. Because they are *always damp:* and the evaporation which they promote, is *constantly absorbing heat* from the earth beneath.

Q. *Why are France and Germany* WARMER *now, than when the vine would not ripen there?*

A. Chiefly because their *vast forests have been cut down;* and the soil is better *drained* and *cultivated.*

Q. *What becomes of the* WATER *of* PONDS *and* TUBS *in summer-time?*

A. Ponds and tubs are often left dry in summer-time, because their water is *evaporated by the air.*

Q. *How is this* EVAPORATION PRODUCED *and carried on?*

A. The heat of the air changes the *surface of the water into vapour*, which (blending with the air) is soon *wafted* *away;* and this process is repeated, till the pond or tub is left quite dry.

Q. *Why are the* WHEELS *of some machines kept constantly* WET *with* WATER?

A. *To carry off* (by evaporation) *the heat* which arises from the *rapid motion* of the wheels.

Q. *Why is mould* HARDENED *by the* SUN?

A. Because the moisture of the mould is exhaled by *evaporation;* and, as the earthy particles are brought *closer* together, the mass becomes more solid.

Q. *Show the wisdom of God in this arrangement.*

A If the soil did not become *crusty* and *hard in dry weather*, the heat and drought would *penetrate the soil,* and kill both seeds and roots.

Q. *Why is* TEA *cooled* FASTER *in a* SAUCER *than in a* CUP?

A. Because *evaporation is increased* by *increasing the surface;* and, as tea in a saucer presents *a larger surface to the* *air*, its heat is more rapidly carried off by evaporation.

The subject of "convection" will be treated of in a future chapter: it would be scarcely understood in this place. See p. 238.

Q. *Why is not the* VAPOUR *of the* SEA SALT?

A. Because the salt of the sea-water is always *left behind*, in the process of evaporation.

Q. *What is that* WHITE CRUST, *which appears (in hot weather) upon* CLOTHES *wetted by sea-water?*

A. Dry *salt*, left on the clothes after the water has evaporated.

Q. *Why does this* WHITE CRUST *always* DISAPPEAR *in* WET *weather?*

A. Because the *moisture of the air dissolves the salt;* in consequence of which, it is no longer visible.

Q. *Why should* NOT *persons, who take violent exercise, wear very* THICK CLOTHING?

A. Because it prevents perspiration from evaporating. When the heat of the body is increased by exercise, *perspiration reduces it again* (by evaporation) to a *healthy standard:* as thick-clothing *prevents* this evaporation, it is injurious to health

CHAPTER XIII.

COMMUNICATION OF HEAT.

1.—CONDUCTION.

Q. *How is heat* COMMUNICATED *from one body to another?*

A. 1.—By Conduction. 2.—By Absorption. 3.—By Reflection. 4.—By Radiation. And 5.—By Convection.

Q. *What is meant by* CONDUCTION *of heat?*

A. Heat communicated from one body to another by *actual contact.*

Q. *Why does not a* PIECE *of* WOOD *(blazing at* ONE *end) feel* HOT *at the* OTHER?

A. Because *wood is so bad a conductor,* that heat does not traverse freely through it: hence, though one end of a stick be blazing, the other end may be quite cold.

Q. *Why do some things feel* COLDER, *than others?*

A. Principally because they are *better* *conductors;* and draw off heat from our body much faster.

Q. *What are the* BEST *conductors of heat?*

A. *Dense solid bodies*, such as metal and stone.

Q. *Which metals are the most* RAPID CONDUCTORS *of heat?*

A. The *best* conductors of heat are 1—gold, 2—silver, 3—copper:

The *next* best are, 4—plat'inum, 5—iron, 6—zinc, 7—tin: Lead is a very *inferior* conductor to any of the preceding metals.

Q. *What are the worst conductors of heat?*

A. All *light* and *porous* bodies; such as hair, fur, wool, charcoal, and so on.

Two of the *worst* conductors known are hare's fur and eider down;—the two next worst are beaver's fur and raw silk; then wood and lamp-black;—then cotton and fine lint; then charcoal, wood ashes, &c.

Q. *Why are cooking vessels often furnished with* WOODEN HANDLES?

A. Because wood is *not a good conductor*, like metal; and, therefore, *wooden* handles prevent the heat of the vessel from rushing into our hands, to burn them

Q. *Why is the* HANDLE *of a* METAL TEAPOT *made of* WOOD?

A. Because wood is a *bad conductor;* therefore, the heat of boiling water is *not so quickly conveyed* to our hand by a wooden handle, as by one made of metal.

Q. *Why would a metal handle* BURN *the* HAND *of the tea-maker?*

A. Because metal is an *excellent conductor;* therefore, the heat of boiling water would *pass so quickly* into the *metal handle,* as to burn the hand.

Q. *Prove that a metal handle would be* HOTTER *than a* WOODEN ONE.

A. If we *touch the metal collar* into which a wooden handle is fixed, we shall find that the wooden handle *feels cold,* but the metal collar *intensely hot.*

Q. *Why do persons use paper or woollen* KETTLE-HOLDERS?

A. Because paper and woollen are both very *bad conductors of heat:* in consequence of which, the heat of the kettle does not *readily pass through them* to the hand.

Q. *Does the heat of a boiling kettle* NEVER *get through the woollen or paper kettle-holder?*

A. Yes; but though the kettle-holder become as hot as the kettle itself, it would never *feel* so hot.

Q. *Why would not the kettle-holder* FEEL *so hot as the kettle, when both are of the same temperature?*

A. Because it is a very *bad* conductor, and disposes of its heat *too slowly* to be *perceptible;* but metal (being an *excellent* conductor) disposes of its heat *so quickly*, that the sudden influx is painful.

Q. *Why does* HOT METAL *feel* MORE *intensely warm, than* HOT WOOL?

A. Because metal gives out a much *greater quantity of heat* in the *same space of time;* and the *influx* of heat is, consequently, *more perceptible.*

Q. *Why does* MONEY *in our pocket feel very* HOT, *when we stand before a* FIRE?

A. Because metal is an excellent conductor, and becomes rapidly heated: For the same reason, it becomes *rapidly cold*, whenever it comes in contact *with* a substance *colder than itself.*

Q. *Why does a* PUMP-HANDLE *feel intensely* COLD IN WINTER?

A. Because it is an *excellent* conductor, and draws off heat from the hand so rapidly, that the sudden loss produces a sensation of intense coldness.

Q. *Is the* IRON *handle of the pump really* COLDER *than the* WOODEN *pump itself?*

A. No: every inanimate substance (exposed to the same temperature) possesses in reality the *same* degree of *heat.*

Q. *Why does the* IRON *handle seem so* MUCH COLDER *than the* WOODEN *pump?*

A. Merely because *iron is a better conductor;* and, therefore, *draws off heat* from the hand more rapidly than wood.

Q. *Why does a polished marble* HEARTH *feel to the feet* COLDER *than a carpet or hearth-rug?*

A. Chiefly because the surface of polished marble allows of a very close contact; and every point in contact draws off heat, till the whole marble is as warm as the foot resting on it.

Stone, marble, and glass, are by no means good conductors, for one part of them may be heated, while another part remains cold.

Q. *If polished marble is a* BAD *conductor, why does it* DIFFUSE *heat?*

A. Because it is so *dense* a substance that its particles lie *very close together*, and can therefore impart heat to each other far more easily than if the particles were further apart.

Q. *Does not the woollen* CARPET *and* HEARTH-RUG, *conduct heat from the human body?*

A. Yes; but being very *bad* conductors, they convey heat away *so slowly*, that its loss is scarcely perceptible

Q. *Is the* COLD HEARTH-STONE *in reality of the* SAME *temperature as the* WARM CARPET?

A. Yes; everything in the room is really of one temperature, though some things feel to the touch colder than others.

Q. *How* LONG *will a hearth-stone feel cold to the feet resting on it?*

A. Till the *feet* and the *hearth-stone* are both of the *same temperature;* and then the sensation of cold in the hearth-stone will go off.

Q. *Why would not the* HEARTH-STONE *feel* COLD, *when it is of the same temperature as our feet?*

A. Because heat would no longer

pass from our feet into the hearth-stone, in order to produce equilibrium.

Q. *When the fire is lighted, why does a polished* MARBLE HEARTH *feel* HOTTER *than the* HEARTH-RUG?

A. Because the polished surface of the marble allows of a much *closer contact* than the hearth-rug, so that it pours heat into the foot from many more points than the loose woollen pile.

Q. *Why does parting with heat* RAPIDLY *make a* HEARTH-STONE *feel* WARM?

A. Because the rapid influx of heat raises the temperature of our body *so suddenly*, that we cannot *help perceiving the increase.*

Q. *Why does the non-conducting power of a* HEARTH-RUG *prevent its feeling so* HOT *as it really is?*

A. Because it parts with its heat *so slowly and gradually*, that we scarcely *perceive* its transmission into our feet.

Q. *When we plunge our* HANDS *into a basin of* WATER, *why does it produce a sensation of cold?*

A. Because water is a *better conductor* than air; and as it draws off heat from our hands *more rapidly*, it feels colder.

Q. *Why does the* CONDUCTING *power of water make it feel* COLDER *than* AIR?

A. Because it *abstracts heat from our hands so rapidly*, that we *feel* its loss; but the air abstracts heat *so very slowly*, that its *gradual loss is hardly perceptible.*

Q. *Is water a* GOOD *conductor of heat?*

A. No; liquids are generally *bad* conductors of heat; but yet water is a *much better conductor* than *air.*

Quicksilver, which is a fluid, is a good conductor of heat, *because it is metallic.*

Q. *Why is* WATER *a* BETTER *conductor of heat, than* AIR?

A. Because *it is more dense:* The conducting power of any substance depends upon its *solidity*, or the *closeness of its particles.*

Q. *How do you know that* WATER *is* NOT *a* GOOD *conductor of heat?*

A. Because it may be made to *boil at its surface*, without imparting sufficient heat to *melt ice a short distance below the surface.*

Q. *Why are not liquids* GOOD *conductors of heat?*

A. Because the heat (which should be transmitted) *produces evaporation*, and *flies off* in the vapour.

Q. *Why does a* POKER *(resting on a fender) feel* COLDER *than the* HEARTH-*rug, which is further off the fire?*

A. Because the poker is an *excellent conductor*, and draws heat from our hand much *more rapidly* than the woollen hearth-rug, which is a very *bad conductor;* though both, therefore, are *equally warm*, the *poker* seems to be the *colder.* (See also p. 193.)

Q. *Why are* HOT BRICKS *(wrapped in cloth) employed in cold weather to keep the feet warm?*

A. Because bricks are *bad conductors* of heat, and cloth or flannel *still worse:* in consequence of which, a hot brick, (wrapped in flannel) will *retain its heat a very long time.*

Q. *Why is a tin pan (filled with* HOT WATER) *employed as a* FOOT WARMER?

A. Because *polished tin* (being a bad radiator of heat) *keeps hot a very long time;* and warms the feet resting upon it.

Q. *What is meant by being a "bad* RADIATOR *of heat?"*

A. To radiate heat is to throw off heat *by rays*, as the sun: a polished tin pan does *not throw off the heat of boiling water* from its surface, but *keeps it in.*

Q. *Why are tin foot-warmers covered with* FLANNEL?

A. 1st—That the *polish* of the tin may not be injured:

2ndly—Because the flannel (being a *very bad conductor*) helps to keep the tin hot *longer:* and

3rdly—Lest the conducting surface of the tin should *feel painfully hot*

Q. *What disadvantage would it be, if the* POLISH *of the tin were injured?*

A. If the tin foot-warmer were to *lose its polish*, it would get cold in a *much shorter time.*

Q. *Why would a tin foot-warmer get* COLD SOONER *if its* POLISH *were* INJURED?

A. Because *polished* tin throws off heat *very slowly;* but dull, scratched, painted, or dirty tin, *throws off heat very quickly.*

Q. *Why are furnaces and stoves (where much* HEAT *is required) built of* POROUS BRICKS?

A. Because bricks are bad conductors, and *prevent the escape of heat;* in consequence of which, they are employed where great heat is required.

Q. *Why are* FURNACE DOORS, *&c., frequently covered with a paste of* CLAY *and* SAND?

A. Because this paste is a *very bad conductor of heat;* and therefore prevents the *escape of heat* from the furnace.

Q. *If a stove be placed in the* MIDDLE *of a room, should it be made of bricks or* IRON?

A. A stove in the *middle of a room* should be made of *iron;* because iron is an excellent *conductor,* and rapidly communicates heat to the air around.

Q. *Why does the Bible say, that* GOD "*giveth* SNOW *like* WOOL?"

A. Because *snow* (being a *very bad conductor of heat*) protects vegetables and seeds from the frost and cold.

Q. *How does the non-conducting power of* SNOW PROTECT VEGETABLES *from the frost and cold?*

A. It prevents the *heat* of the earth from being *drawn off* by the cold air, which rests upon it.

Q. *Why are* WOOLLENS *and* FURS *used for clothing in cold weather?*

A. Because they are *very bad conductors* of heat: and, therefore, prevent the warmth of our body from being *drawn off* by the cold air.

Q. *Do not woollens and furs actually* IMPART *heat to the body?*

A. No; they merely prevent the heat of the body from *escaping.*

Q. *Where would the heat* ESCAPE *to, if our body were* NOT *wrapped in wool or fur?*

A. Into the air; for cold air (coming in contact with our body) would gradually *draw away its heat,* till both were of the same temperature.

Q. *What is the principal use of* CLOTHING *in winter time?*

A. 1st—To prevent animal heat from escaping too freely: and

2ndly—To protect our body from the *external air* (or wind), which would carry away its heat too rapidly.

Q. *Why are beasts covered with* FUR, HAIR, *or* WOOL?

A. Because fur, hair, and wool, are *very slow* conductors of heat; and (as dumb animals cannot be clad, like human beings) God has given them a robe of hair or wool, to keep them warm.

Q. *Why are birds covered with* DOWN *or* FEATHERS?

A. Because down and feathers are *very bad* conductors of heat; and (as birds cannot be clad, like human beings) God has given them a robe of feathers, to keep them warm.

Q. *Show how the goodness of God is manifested, even in the clothing of* BIRDS *and* BEASTS.

A. Small birds, which are the most *delicate*, have a *thicker* covering of feathers, than those which are larger and more hardy: and beasts which live in the cold regions of the frigid zones have *thicker*, *coarser*, and *warmer* coats, than those which dwell in the tropical heat.

Q. *Why are* FURS, HAIR, *and* FEATHERS, *such* SLOW *conductors of heat?*

A. Because a great *quantity of air* lurks entangled between their fibres; and *air* is a *very bad* conductor of heat.

The warmest clothing is that which fits the body very *loosely* in every part except at the *extremities*; because more hot air will be confined by a *loose* garment, than by one which fits the body *tightly*.

Q. *If* AIR *be a* BAD *conductor of heat, why should we not feel as warm* WITHOUT *clothing, as when wrapped in wool and fur?*

A. Because the air *is never at rest;* and every fresh particle which comes in contact with our body, *carries off* a fresh portion of heat.

Q. *Does the* AIR, *which surrounds a naked body, become (by contact) as* WARM *as the* BODY *itself?*

A. It would do so if it remained *motionless;* but, as it remains only a *very short time*, it absorbs as much heat as it can in the time, and passes on.

Q. *Why do we feel* COLDER *in* WINDY WEATHER, *than in a* CALM *day?*

A. Because the particles of air pass over us *more rapidly;* and every *fresh* particle takes from us *some* portion of heat.

This effect will be greatly influenced by the temperature of the wind.

Q. *Show the wisdom of God in making* AIR *a* BAD *conductor.*

A. If air were a *good conductor* (like iron and stone) heat would be drawn *so rapidly* from our body, that we should be *chilled to death.* Similar evils would be felt also by *all* the animal and vegetable world.

Q. *Does* HOT *air give heat as slowly to our body, as* COLD *air takes it away?*

A. Yes. A man may go into air of the temperature of 300°, without having the heat of his body raised more than two or three degrees.

Workmen enter ovens, in the manufacture of moulds of plaster of Paris, in which the thermometer stands 100° higher than the temperature of boiling water, and take no harm. The precaution must be taken, to have no metal in contact with the person; a gentleman who once entered a hot-air oven with spectacles on, was severely burnt; the metal frame became rapidly heated, being a good conductor, and communicated the heat to his nose.

Q. *Could as high a temperature be borne, when the* AIR *is in* MOTION?

A. No. The effect of the heated air becomes more *intense* when it is in *motion*, because *fresh* portions are then continually applied to the surface of our body.

Q. *Can all bodies be touched without inconvenience, when their temperature is as high as* 300°?

A. No. Metals cause pain when their temperature is 120°: water scalds when its temperature is 150°.

Q. *Why does* FANNING *one's face in summer make it* COOL?

A. Because the fan *puts the air in motion*, and makes it pass more *rapidly over one's face;* and (as the temperature of the *air* is always *lower* than that of the human *face*) each puff of air *carries off* some portion of its heat.

Q. *Does* FANNING *make the air itself cooler?*

A. No: fanning makes the *air hotter and hotter.*

Q. *How does* FANNING *one's face increase the* HEAT *of the air?*

A. By driving the air more rapidly over the human body; and causing it to *absorb more heat.*

Q. *If fanning makes the air* HOTTER, *why can it make a person feel* COOLER?

A. Because it takes heat *out of the face*, and gives it to the *air.*

Q. *Why is broth* COOLED *by* BLOWING *it?*

A. Because the breath causes a rapid *change of air* to pass over the broth; and (as the air is colder than the broth) it continually *absorbs heat* from it, and makes it cooler and cooler.

Q. *Would not the air absorb heat from broth just as well* WITHOUT BLOWING?

A. No; *air is a very bad conductor*; unless, therefore, the *change be rapid*, that portion of air nearest the surface of the broth would soon become *as hot* as the broth itself.

Q. *Would not hot air* PART *with its heat instantly to the* CIRCUMJACENT *air?*

A. No; not instantly. Air is so bad a conductor, that it parts with its heat *very slowly;* unless, therefore, it be kept in *continual motion*, it would cool the broth *very slowly* indeed.

Q. *Why does* WIND *generally feel* COOL?

A. Because it drives the air more rapidly over our body; and this rapid *change* of air, draws off a large quantity of heat.

Q. *Why does air* ABSORB *heat more* QUICKLY *by being set in* MOTION?

A. Because every fresh portion of air *absorbs a fresh amount of heat;* and the more rapid the *current of air*, the greater will be the quantity of heat absorbed.

Q. *If the air were hotter than our body, would the* WIND *feel* COOL?

A. No; if the air were *hotter* than our body, it would feel insufferably warm.

Q. *Why would the air feel unpleasantly* HOT, *if it were* WARMER *than our* BODY?

A. Because it would *add* to the heat of our body, instead of *diminishing* it.

Q. *Is the* OPEN AIR *ever as* HOT *as the human body?*

A. Not in *this* country; in the hottest summer's day, the air is at least 10 or 12 degrees *cooler* than the human body.

Q. *Is the* EARTH *a good conductor of heat?*

A. No; the earth is a *bad* conductor of heat.

Q. *Why is the earth a* BAD *conductor of heat?*

A. Because its particles are not *continuous:* The power of *conducting* heat depends upon the *continuity of matter.*

Q. *Why is the earth* (BELOW *the surface*) WARMER *in winter, than the surface itself?*

A. Because the earth is a *bad* conductor of heat; and, therefore, (although the ground be frozen) the frost never penetrates more than a *few inches below the surface.*

Q. *Why is the earth* (BELOW *the surface*) COOLER *in summer, than the surface itself?*

A. Because the earth is a *bad* conductor of heat; and, therefore, (although the *surface be scorched* with the burning sun), the intense heat cannot penetrate to the *roots* of the plants and trees.

Q. *Show the* WISDOM *of* GOD *in making the* EARTH *a* BAD *conductor.*

A. If the *heat and cold* could penetrate the earth (as freely as the heat of a fire penetrates iron) the springs would be dried up in summer, and frozen in winter; and all vegetation would be soon destroyed.

Q. *Why is water from a* SPRING *always* COOL, *even in summer?*

A. Because the earth is so *bad a conductor*, that the rays of the sun can penetrate only a few inches below the surface; in consequence of which, the *springs* of water are *not affected* by the heat of summer.

Q. *Why is it* COOL *under a* SHADY *tree, in a hot summer's day?*

A. 1st—Because the overhanging foliage *screens* off the rays of the sun:

2ndly—As the rays of the sun are

warded off, the *air* (beneath the tree) is not heated by the *reflection* of the earth: and

3rdly—The leaves of trees are good radiators of heat; and, therefore, send *back* to the earth a great deal of that which they receive.

Dew forms upon leaves early in the evening, because the air cools down quickly by rapid radiation. (See p. 210, &c.)

Q. *Why do Laplanders wear* SKINS, *with the* FUR INWARDS?

A. 1st—Because *dry skins* prevent the *wind* from penetrating to their body; and

2ndly—The *air* (between the hairs of the fur) soon becomes *heated* by the heat of the body; in consequence of which, the Laplander in his fur is clad in a case of *hot air*, impervious to cold and wind.

Q. *Why does a* LINEN *shirt feel* COLDER *than a* COTTON *one?*

A. Because *linen* is a *much better conductor* than cotton; and, therefore draws away animal heat *more rapidly*, and produces a greater sensation of cold.

Q. *Does fine or coarse* WOOLLEN *cloth make the* WARMEST *clothing?*

A. The *finer* the cloth, the more

slowly it conducts heat. Fine cloths, therefore, are warmer than coarse ones.

Q *Is* SILK *a good conductor of heat?*

A. No; it is a bad conductor of heat. Spun silk allows the heat of the body to pass off more quickly than wool; but raw silk confines it more than wool. (p. 172).

Count Rumford found that when a thermometer cooled down 135° in air in 575 seconds, it did not cool down to the same extent in less than 917 seconds, when surrounded by *spun* silk; in 1046 seconds, when surrounded by cotton wool; in 1118 seconds, when surrounded by sheep's wool; in 1284 seconds, when surrounded by raw silk; and in 1305 seconds, when surrounded by eider down.

Q. *Why is our* FACE COOLED *by wiping the temples with a fine cambric handkerchief?*

A. Because the fine fibres of the cambric have a strong capillary attraction for *moisture*, and are excellent *conductors* of heat: in consequence of which, the moisture and heat are *abstracted* from our face by the cambric, and a sensation of coolness produced.

"Capillary attraction," i.e. *the attraction of a thread or hair.* The wick of a candle is wet with grease, because the melted tallow runs up the cotton from capillary attraction.

Q. *Why would not a* COTTON *handkerchief do as well?*

A. Because the coarse fibres of cotton

have very little capillary attraction, and are *very bad* conductors; in consequence of which, the heat of our face would be *increased* (rather than *diminished*) by the use of a *cotton* handkerchief.

CHAPTER XIV.

2.—ABSORPTION OF HEAT.

Q. *What is the difference between* CONDUCTING *heat, and* ABSORBING *heat?*

A. To *conduct* heat, is to *transmit it* from one body to another through a *conducting* medium: To *absorb* heat, is to *suck it up*, as a sponge sucks up water.

Q. *Give me an example.*

A. *Black cloth absorbs*, but does not *conduct heat*: thus, if black cloth be laid in the sun, it will *absorb the rays* very rapidly; but if *one end* of the black cloth be made hot, it would not *conduct* the heat to the other end.

Q. *Are good* CONDUCTORS *of heat, good* ABSORBERS *also?*

A. No; every *good conductor* of heat is a *bad absorber* of it: and *no good absorber* of heat can be a *good conductor* also.

Q. *Is* IRON *a good* ABSORBER *of heat?*

A. No; *iron* is a *good conductor*, but a very *bad absorber* of heat.

The power of absorbing heat depends on the nature of the surface of a body; thus, bright or polished surfaces will not absorb heat so readily as rough and black ones.

Q. *Why do the* FIRE-IRONS *(which lie upon a* FENDER*) remain* COLD, *although they are before a good fire?*

A. Because they are *bad absorbers* of heat: in consequence of which, they remain *cold*, unless they come in *contact* with the stove or fire.

Q. *Why are the* FIRE-IRONS *intensely* HOT, *when they rest* AGAINST *a* STOVE *which contains a good fire?*

A. Because they are *excellent conductors* of heat, and draw it rapidly from the stove with which they are in contact.

Q. *Why does a* KETTLE *boil faster, when the bottom and back are covered with* SOOT?

A. Because the black soot *absorbs* heat very quickly from the fire, and the metal *conducts* it to the water.

Q. *Why will not a* NEW KETTLE *boil so fast as an* OLD *one?*

A. Because the *bottom* and *sides* of a new kettle are *clean* and *bright:* but in *an old* kettle they are *covered with soot.*

Q. *Why would a* KETTLE BOIL *more* SLOWLY, *if the bottom and back were clean and bright?*

A. Because *bright* metal does *not absorb heat*, but *reflects* it: and (as the heat is *thrown off* from the surface of *bright* metal by reflection), therefore, a new kettle takes a longer time to boil.

Reflects heat, i.e. throws it off.

Q. *Why do we wear a* BLACK *outer* DRESS, *if we want to be warm?*

A. Because a *black outer dress* quickly *absorbs heat* from the sun's rays.

Q. *Why do persons* WEAR WHITE *dresses in* SUMMER *time?*

A. Because white *throws off the heat* of the sun by reflection, and is a very bad absorbent of heat; in consequence of which) white dresses never become *so hot from the scorching sun*, as dark colours do.

Q. *Why do* NOT *persons wear* WHITE *dresses in* WINTER *time?*

A. Because white will *not absorb heat* like black and other dark colours; and, therefore, *white dresses are not so warm as dark* ones.

Q. *What* COLOURS *are* WARMEST *for dresses?*

A. For *outside* garments *black* is the *warmest*, and then such colours as approach nearest to black (as dark blue and green). *White* is the *coldest* colour for external clothing.

Q. *Why are* DARK *colours (for external wear) so much* WARMER *than* LIGHT *ones?*

A. Because *dark colours absorb heat* from the sun more abundantly than *light* ones.

Q. *How can you prove that* DARK *colours are* WARMER *than* LIGHT *ones?*

A. If a piece of *black* and a piece of *white* cloth were laid upon snow, in a few hours the *black cloth* will have *melted the snow beneath;* whereas, the *white* cloth will have produced little or *no effect upon it at all.*

N.B. The *darker* any colour is, the *warmer* it is, because it is a better absorbent of heat. The order may be thus arranged:—1. Black (warmest of all)—2. Violet.—3. Indigo.—4. Blue.—5. Green.—6. Red.—7. Yellow.—8. White (coldest of all).

Q. *Why are* BLACK KID GLOVES *unpleasantly* HOT *for summer wear?*

A. 1st—Because *black absorbs the solar heat:* and

2ndly—*Kid* will not allow the heat of our hand to *escape through the glove.*

Q. *Why are* LISLE THREAD GLOVES *agreeably* COOL *for summer wear?*

A. 1st—Because thread *absorbs perspiration:* and

2ndly—It *conducts away* the heat of our hot hands.

Q. *Are Lisle thread gloves* ABSORBENTS *of heat?*

A. No; Lisle thread gloves are generally of a *grey or lilac colour:* and, therefore, *do not absorb solar heat.*

Q. *Why is a* PLATE-WARMER *made of* UNPAINTED *bright tin?*

A. Because bright tin *reflects the heat* (which issues from the fire in rays) upon the meat; and, therefore, greatly assists the process of roasting.

Reflects the heat, i.e. throws it *back* upon the meat.

Q. *Why would not the tin* REFLECTOR *do as well, if it were* PAINTED*?*

A. Because it would then *absorb* heat,

and *not reflect it so well.* A plate-warmer should never be *painted*, but be kept *very clean*, *bright*, and *free from all scratches.*

Q. *Why should a* REFLECTOR *be kept so very* CLEAN, *and free from all* SCRATCHES?

A. Because, if a reflector were *spotted*, *dull*, *or scratched*, it would *absorb* heat, instead of *reflecting* it; and, consequently, would be of no use whatsoever as a *reflector.*

Q. *Why does* HOAR-FROST *remain on* TOMB-STONES, *long after it has melted from the grass and gravel-walks of a church-yard?*

A. Because tomb-stones (being *white*) will *not absorb heat*, like the darker grass and gravel; in consequence of which, they remain too *cold* to thaw the frost congealed upon their surface.

Q. *If black absorbs heat, why have those who live in* HOT *climates* BLACK *skins, and not* WHITE *skins, which would not absorb heat at all?*

A. Because *black* will not *blister* from the heat of the sun. Although, therefore, the black skin of a negro *absorbs heat* more plentifully than the *white skin of a*

European; yet the *blackness* prevents the sun from *blistering* or *scorching it.*

Q. *How is it known, that* BLACK *colour prevents the sun from either* BLISTERING *or* SCORCHING *the skin?*

A. If you place a *white cloth glove* over *one hand,* and a *black cloth one* on the *other,* (when the sun is burning hot,) the hand with the *white cloth* covering will be *scorched,* but *not the other.*

Q. WHICH *hand will* FEEL *the* HOTTER?

A. The hand covered with *black cloth* will *feel* the *hotter,* but will not be *scorched* by the sun: whereas, the hand covered with *white cloth* (though much *cooler*) will be *severely scorched.*

Q. *Why does the* BLACK *skin of a* NEGRO *never* SCORCH *or* BLISTER *with the hot sun?*

A. Because the *black colour absorbs* the heat, and conveys it *below the surface* of the skin.

Q. *Why does the* WHITE *European skin* BLISTER *and* SCORCH, *when exposed to the hot sun?*

A. Because *white will not absorb* heat; and, therefore, the hot sun *rests on the surface of the skin,* and *scorches* it.

Q. *Why has a negro* BLACK EYES?

A. Because the black colour defends them from the strong light of the tropical sun. If a negro's eyes were not black, the sun would so *dazzle them*, that the negro might become blind.

Q. *Why is* WATER *(in hot weather) kept* COOLER *in a* BRIGHT TIN POT *than in an earthen one?*

A. Because bright metal will *not absorb* heat from the hot air, like an *earthen* vessel; in consequence of which, the water is kept *cooler.*

Boiling water is also kept *hot* in bright metal, better than in earthen vessels. (See p. 209.)

CHAPTER XV.

3.—REFLECTION OF HEAT.

Q. *What is meant by* REFLECTING *heat?*

A. To reflect heat, is *to throw it back in rays* from the surface of the reflecting body, towards the place whence it came.

Q. *What are the* BEST *reflectors of heat?*

A. All *bright* surfaces, and *light* colours.

Q. *Are good* ABSORBERS *of heat good* REFLECTORS *also?*

A. No: those things which *absorb* heat *best*, *reflect* heat *worst;* and those which *reflect* heat *worst*, *absorb* it *best.*

Q. *Why are those things which* ABSORB *heat, unable to* REFLECT *it?*

A. Because the same heat cannot be both *absorbed* and *reflected:* if absorbed or taken *into* a substance, it cannot also be *thrown off* from its surface: and if *thrown off* from the surface, it cannot also be taken *into* the substance.

Q. *Why are* REFLECTORS *always made of* LIGHT-COLOURED *and highly*-POLISHED METAL?

A. Because *light*-coloured and highly-*polished metal* makes the best of all reflectors.

Q. *Why do not plate-warmers blister and scorch the* WOOD *behind?*

A. Because the bright tin front throws the heat of the fire *back again*, and will not allow it to penetrate to the wood behind.

Q. *If metal be such an excellent* CONDUCTOR *of heat, how can it* REFLECT *heat, or throw it off?*

A. Polished metal is a *conductor of heat*, only when that heat is communicated by *actual contact:* But, whenever heat falls upon bright metal in *rays*, it is *reflected back* again, and the metal remains *cool.*

Q. *What is meant by "heat falling upon metal in* RAYS," *and not "by contact?"*

A. A piece of metal thrust *into* a fire would be in *actual contact with that fire;* but if *held before a fire*, the heat of the fire would fall upon it in *rays.*

Q. *What is the use of the* TIN SCREEN *or reflector, used in* ROASTING?

A. It throws the heat of the fire *back upon the meat:* and, therefore, both assists the process of *roasting*, and helps to *keep the kitchen cool.*

Q. *How does a tin reflector tend to keep the* KITCHEN COOL?

A. By *confining the heat* of the fire to the *hearth*, and preventing its dispersion throughout the kitchen.

Q. *Why are* SHOES HOTTER *for being* DUSTY?

A. Because dull dusty shoes will *absorb heat* from the sun, earth, and air; but shoes brightly polished, *throw off* the heat of the sun by reflection.

Q. *Why does it always* FREEZE *on the* TOP *of a* HIGH *mountain?*

A. 1st—Because air is heated by *contact with the earth's surface*, and not by solar rays which pass *through it:* As a mountain-top affords very small surface for such contact, it remains intensely cold; and

2ndly—When air flows up the side of a mountain, it *expands* from diminished pressure; and consequently absorbs heat from surrounding objects.

Rarefied air can hold more latent heat than dense air can.

CHAPTER XVI.

4.—RADIATION.

Q. *What is meant by* RADIATION?

A. Radiation means *the emission of rays:* Thus, the sun radiates both light and heat; that is, it emits *rays of light and heat* in all directions.

Q. *When is heat* RADIATED *from one body to another?*

A. When the two bodies are *separated* by a *non-conducting medium:* thus, the sun *radiates* heat towards the earth, because the *air* (which is a very bad conductor) *comes between.*

Q. *On* WHAT *does radiation depend?*

A. On the *roughness* of the radiating surface: thus, if metal be *scratched,* its radiating power is increased; because the *heat has more points to escape from.*

Q. *Does a fire radiate heat?*

A. Yes; and because *burning fuel emits rays of heat,* therefore, we *feel warm* when we stand before a fire.

Q. *Why does our* FACE *feel uncomfortably* HOT, *when we approach a fire?*

A. Because the fire radiates heat upon it; and (not being covered) it feels the effect immediately.

Q. *Why does the fire catch our* FACE *more than it does the* REST *of our body?*

A. Because the rest of our body is

covered with clothing; which (being a *bad* conductor) prevents the same sudden and rapid transmission of heat to our skin.

Q. *Do those substances which* RADIATE *heat,* ABSORB *heat also?*

A. Yes. Those substances which *radiate most,* also *absorb most heat:* and those which *radiate least,* also *absorb the least* heat.

Q. *Does any thing* ELSE *radiate heat, besides the* SUN *and* FIRE?

A. Yes; *all* things radiate heat in *some* measure, but *not equally well.*

Q. *What things* RADIATE *heat the* NEXT BEST *to the sun and fire?*

A. All *dull* and *dark* substances are *good radiators* of heat: but all *light* and *polished* substances are *bad radiators.*

Q. *Why should the* FLUES *(connected with Arnott's stoves, &c.) be always blackened with* BLACK LEAD?

A. In order that the heat of the flue may be more readily *diffused* throughout the room. Black lead radiates heat more freely, than any other known substance.

A better name for black lead is "graphite," because it contains no metallic lead, but is a mixture of *carbon and iron*. It is used chiefly in black-lead pencils; and hence its name, from the Greek word γραφειν *to write*. The black lead used for domestic purposes contains only a small portion of true "graphite."

Q. *Why does a* POLISHED *metal tea-pot make* BETTER *tea than a black earthen one?*

A. Because polished metal, (being a very *bad radiator* of heat) *keeps the water hot much longer;* and the hotter the water is, the better it "draws" the tea.

Q. *Why does not a* DULL *black tea-pot make good tea?*

A. Because the heat of the water *flies off so quickly* through the dull black surface of the tea-pot, that the water is very *rapidly cooled*, and cannot "draw" the tea.

Q. *Why do pensioners, and aged cottagers, generally prefer the little black* EARTHEN *tea-pot to the bright* METAL *one?*

A. Because they *set it on the hob*, "*to draw*;" in which case, the little *black tea-pot* will make the *best* tea.

Q. *Why will a* BLACK *tea-pot make better tea than a bright* METAL *one, if set upon the* HOB *to* DRAW?

A. Because the black tea-pot will

absorb *heat plentifully* from the fire, and keep the water *hot:* whereas, a bright *metal* tea-pot (set upon the hob) would *throw off* heat by *reflection.*

Q. *Then sometimes a* BLACK EARTHEN *tea-pot is the best, and sometimes a bright metal one?*

A. Yes; when a tea-pot is *set on the hob* "*to draw,*" black *earth* is the *best*, because it *absorbs heat:* But, when a tea-pot is *not* set on the hob, bright *metal* is the *best;* because it *radiates heat very slowly*, and therefore *keeps the water hot.*

Q. *Why does a* SAUCEPAN, *which has been* USED, *boil in a shorter time than a* NEW *one?*

A. Because the bottom and back are *covered with soot:* and *black soot* rapidly *absorbs heat* from glowing coals.

Q. *Why should the* FRONT *and* LID *of a* SAUCEPAN *be clean and bright?*

A. Because they cannot *absorb* heat, as they do not come in contact with the fire; and (being bright) they will not suffer the heat inside them to *escape* by radiation.

Q. *In what state should a saucepan be, in order that it may* BOIL *most* QUICKLY?

A. All those parts, which come in contact *with the fire*, should be covered with *soot*, in order to absorb heat; but all the *rest* should be as *bright* as possible to prevent the *escape* of heat by radiation.

Q. *Why is it said that* "SATURDAY'S KETTLE *boils the* FASTEST?"

A. Because on Saturday, the *front* and *top* of the kettle are generally *cleaned* and *polished;* but the *bottom* and *back* of the kettle are *never* cleaned.

Q. *Why should* NOT *the* BOTTOM *and* BACK *of a kettle be clean and polished?*

A. Because *they come in contact with the fire*, and (while they are covered with black soot) *absorb heat freely* from the burning coals.

Q. *Why should the* FRONT *and* TOP *of a kettle be clean and well polished?*

A. Because polished metal *will not radiate heat;* and, therefore, (while the front and top of a kettle are well polished) *the heat is kept in*, and not suffered to escape by radiation.

Q. *Why does the* BOTTOM *of a kettle feel nearly cold when the water is boiling* HOT?

A. Because black soot is a very *bad conductor of heat;* and, therefore, the heat of the boiling water is some time before it gets *through the soot*, which adheres to the bottom of the kettle.

Q. *Why is the* LID *of a* KETTLE *intensely* HOT, *when the water boils?*

A. Because the bright metal lid is an *admirable conductor;* and, therefore, *heat* from the *boiling water pours into our hand* the moment we touch it.

Q. *Show the benefit of* SMOKE *in* COOKING.

A. The carbon of the fuel (which flies off in smoke) naturally *blackens* all culinary vessels set upon a fire to boil, and thus renders them fit for use.

"Culinary vessels" are vessels used in kitchens for cooking, as saucepans, boilers, kettles, &c., from the Latin word "Culi'na," (*a kitchen*).

Q. *How does* SMOKE *make culinary vessels* FIT *for* USE?

A. By covering them with soot. If it were not for the soot (which gathers round a kettle or saucepan) heat would *not be absorbed*, and the process of boiling would be greatly retarded.

Q. *Why is boiling water kept* HOT *in a bright* METAL *pot, better than in an earthen vessel?*

A. Because bright metal (being a *bad radiator*) will not *throw of from its surface* the heat of the boiling water.

Q. *Why would not a metal pot serve to keep water hot if it were* DULL *and* DIRTY?

A. Because it is the bright *polish* of the metal, which makes it a bad radiator; and if it were *dull*, *scratched*, or *dirty*, heat would *escape* very rapidly.

Water in hot weather is also kept *cooler* in bright metal than in *dull* or earthen vessels. (*See p.* 199.)

Q. *Why are dinner-covers made of* BRIGHT TIN *or* SILVER?

A. Because light-coloured and highly-polished metal is a *very bad radiator of heat;* and, therefore, bright tin or silver will not allow the heat of the cooked food to *escape through the cover by radiation.*

Q. *Why should a* MEAT-COVER *be very brightly* POLISHED?

A. To prevent the heat of the food from escaping by *radiation*. If a meat-cover be *dull* or *scratched*, it will *allow the heat of the food beneath* to fly off into the room.

Q. *Why should a silver meat-cover be* PLAIN, *and not enchased?*

A. Because a *chased* meat-cover would not prevent the radiation of heat so perfectly as a plain one.

Q. *What is* DEW?

A. Dew is the *vapour* of the air *condensed*, by coming in contact with bodies *colder* than itself.

Q. *Why is the* GROUND *sometimes* COVERED *with* DEW?

A. Because the surface of the earth (at sunset) is made so *cold* by radiation, that the warm vapour of the air is chilled, by contact, and condensed into dew

Q. *Why is the earth* COLDER *than the* AIR, *after the sun has set?*

A. Because the earth *radiates* heat very freely, but the air does not; in consequence of which, the earth is often 5 or 10 degrees colder than the air (after sunset); although it was much *warmer* than the air, during the whole day.

Q. *Why is the earth* WARMER *than the* AIR, *during the day?*

A. Because the earth *absorbs* solar heat very freely, but the air does not; in consequence of which, it is often many degrees warmer than the air, during the day.

Q. *Why is the surface of the ground* COLDER *in a* FINE *clear night, than in a* CLOUDY *one?*

A. Because on a fine clear star-light night, heat *radiates* from the earth *freely*, and is lost in open space: but on a *dull* night, the clouds *arrest* the process of *radiation.*

Q. *Why is* DEW *deposited only on a* FINE *clear* NIGHT?

A. Because the *surface* of the ground *radiates* heat most freely on a fine night; and (being cooled down by this loss of heat) *condenses* the vapour of the *air* into *dew.*

Q. *Why is there no* DEW *on a dull* CLOUDY *night?*

A. Because clouds *arrest* the radiation of *heat* from the earth; and (as the heat cannot freely escape) the earth's surface is not sufficiently cooled down, to *condense* the vapour of the air *into dew.*

Q. *Why is a cloudy night* WARMER *than a fine one?*

A. Because clouds *prevent the radiation of heat* from the *earth;* in consequence of which, the surface of the earth remains *warmer.*

Q. *Why is* DEW *most abundant in situations most* EXPOSED?

A. Because the radiation of heat *is not arrested* by houses, trees, hedges, or any other things.

Q. *Why is there scarcely any* DEW *under a* TREE *when in full foliage?*

A. 1st—Because the thick foliage *arrests the radiation of heat* from the earth: and

2ndly—It radiates some of its own heat *towards the earth;* in consequence of which, the ground underneath a leafy tree is not sufficiently cooled down, to chill the vapour of the air into dew.

Q. *Why is there never much* DEW *at the foot of* WALLS *and* HEDGES?

A. 1st—Because they act as screens, *to arrest the radiation of heat* from the earth: and

2ndly—They themselves *radiate some portion of heat* towards the earth: in consequence of which, the ground at the foot of walls and hedges is not sufficiently *cooled down*, to condense the vapour of the air into dew.

Q. *Why is there little or* NO DEW *beneath a* FLOWER-AWNING, *although that awning be open on all four sides?*

A. 1st—Because the awning *arrests* the radiation of heat from the *ground* beneath: and

2ndly—It *radiates* some of its own heat *downwards;* in consequence of which, the ground beneath an awning is not sufficiently cooled down, to chill the vapour of air into dew.

Q. *How can a thin covering of* BASS *or even* MUSLIN, *protect trees from* FROST?

A. Because *any covering* prevents the radiation of heat from the tree; and if trees are *not cooled down* by radiation, the vapour of the air will *not be frozen,* as it comes in contact with them.

Bass, *pronounce* bas—a kind of matting used by gardeners.

Q. *Why is the* BASS *or* CANVASS *itself (which covers a tree) always drenched with* DEW?

A Because it *radiates heat* both *up-*

wards and downwards; in consequence of which, it is *so cooled down*, that it readily *condenses the vapour* of the *air* into *dew.*

Q. *Why does* SNOW *(at the foot of a* HEDGE *or* WALL) *melt sooner than that in an open field?*

A. Because hedges or walls *radiate heat into the snow*, which melts it.

Q. *Why is there* NO DEW *after a* WINDY NIGHT?

A Because wind *evaporates the moisture*, as fast as it is deposited.

Q. *Why are* VALLEYS *and* HOLLOWS *often thickly covered with* DEW, *although they are sheltered?*

A. Because surrounding hills prevent the *repose* of air from being *disturbed;* but do not *overhang* and *screen* the valleys sufficiently to *arrest* radiation.

Q *Why does* DEW *fall more abundantly on* SOME *things, than on others?*

A. Because some things radiate heat *more freely* than others; and, therefore, become *much cooler* in the night.

Q. *Why are things which radiate heat most*

FREELY, *always the most* THICKLY COVERED *with* DEW?

A. Because the vapour of the air is *condensed into dew*, the moment it comes in contact with them.

Q. WHAT *kind of things radiate heat most* FREELY?

A. Grass, wood, and the leaves of plants, radiate heat *very freely;* but polished metal, smooth stones, and woollen cloth, part with their heat *very tardily.*

Q. *Do the leaves of* ALL *plants radiate heat* EQUALLY *well?*

A. No. Rough *woolly leaves* (like those of a holly-hock) radiate heat much *more freely*, than the *hard smooth polished leaves* of a common laurel.

Q. *Shew the* WISDOM *of* GOD *in making grass, the leaves of trees, and* ALL VEGETABLES, *excellent radiators of heat.*

A. As vegetables *require much moisture*, and would often *perish* without a plentiful deposit of dew, God wisely made them to *radiate heat freely*, so as to *condense the vapour* (which touches them) *into dew.*

Q. *Will polished* METAL, *smooth* STONES, *and woollen* CLOTH, *readily collect* DEW?

A. No. While grass and the leaves of plants are completely *drenched with dew*, a piece of *polished metal*, or of *woollen cloth* (lying on the same spot), will be *almost dry*.

Q. *Why would polished* METAL *and woollen* CLOTH *be* DRY, *while grass and leaves are drenched with* DEW?

A. Because polished metal and woollen cloth *part with their heat so slowly*, that the vapour of the air is *not condensed into dew*, when it passes over them.

Q. *Why is a gravel walk almost* DRY, *when a grass plat is thickly covered with* DEW?

A. Because *grass* is a good *radiator*, and throws off its heat very *freely*; but *gravel* is a *bad radiator*, and parts with its heat slowly.

Q. *Is that the reason why* GRASS *is saturated with* DEW, *and the gravel is* NOT?

A. Yes. When the vapour of warm air comes in contact with the *cold grass*, it is instantly deposited as dew; but it is *not so freely condensed*, as it passes over the warmer gravel.

Q. *Why is* DEW *rarely distilled upon hard rocks and barren lands?*

A. Because rocks and barren lands are so *compact* and *hard*, that they can neither absorb nor radiate *much heat:* and (as their temperature varies *very little*) very little *dew* distils upon them.

Q. *Why does* DEW *fall more abundantly on cultivated soils than on barren lands?*

A. Because cultivated soils (being *loose* and *porous*,) very freely *radiate* by night, the heat which they absorbed by day; in consequence of which, they are much *cooled* down, and plentifully *condense* the vapour of the passing air into *dew*.

Q. *Shew the* WISDOM *of God in this arrangement.*

A. Every plant and each portion of land, which *needs* the moisture of dew, is adapted to *collect* it; but *not a single drop* is *wasted*, where its refreshing moisture is *not required*.

Q. *Shew the* WISDOM *of* GOD *in making polished metal and woollen cloth* BAD RADIATORS *of heat.*

A. If polished metal collected dew as

easily as grass, it could never be kept dry and *free from rust.* Again, if woollen garments collected dew as readily as the leaves of trees, we should be often *wet*, and subject to the risk of "taking cold."

Q. *Shew how this affords a beautiful illustration of* GIDEON'S MIRACLE, *recorded in the book of Judges*, VI. 37, 38.

A. The *fleece of wool* (which is a very *bad* radiator of heat) was *wet* with dew: when the *grass* (which is a most excellent radiator) was quite *dry*.

Q. *Was not this* CONTRARY *to the laws of nature?*

A. Yes: and was, therefore, a plain demonstration of the *power of God*, who could thus change the very *nature* of things at his will.

Q. *Why do our* CLOTHES *feel* DAMP, *after walking in a fine evening in* SPRING *or* AUTUMN?

A. Because vapour (condensed by the cooling of the air) is deposited upon them, like dew.

Q. *Why are* WINDOWS *often covered with thick* MIST, *and the frames wet with standing* WATER?

A. Because the temperature of the

external air always *falls* at sun-set, and *chills* the *window-glass*, with which it comes in contact.

Q. *How does this account for the* MIST *and* WATER *on a window?*

A. As the warm vapour of the room *touches* the *cold glass*, it is *chilled* and *condensed* into *mist;* and the mist (collecting into drops) *rolls* down the window-frame in little streams of water.

Q. *Why does the* GLASS *of a window* COOL *down more rapidly, than the air of the room itself?*

A. Because the air of the room is *kept warm* by fires, and *animal heat;* in consequence of which, it suffers very *little* diminution of heat from the setting of the sun.

Q. *Whence arises the* VAPOUR *of a room?*

A. 1st—The *air* of the room itself naturally contains *vapour:*

2ndly—The *breath* and *insensible* perspiration of the inmates *increase* this vapour: and

3rdly—*Hot dinners*, the *steam of tea*, and so on, increase it still more.

Q. *What is meant by* "INSENSIBLE *perspiration?*"

A. From every part of the human body, an *insensible* and *invisible perspiration* issues all night and day; not only in the hot weather of *summer*, but also in the coldest day of *winter.*

Q *If the perspiration be both* INSENSIBLE *and* INVISIBLE, *how is it known that there* IS *any such perspiration?*

A. If you put your naked arm into a clean dry *glass tube*, the *perspiration* will *condense* on the glass, like mist.

Q *Why are carriage windows very soon covered with thick* MIST?

A. Because the warm vapour of the carriage is *condensed* by the *cold glass*, and covers it with a thick mist.

Q. *Why is the glass window* COLD *enough to condense the vapour of the carriage?*

A. Because the *inside* of the carriage is much *warmer* than the *outside;* and the glass window is made cold by contact with the *external air.*

Q. *Where does the* WARM *vapour of the carriage come from?*

A. From the warm *breath* and

insensible *perspiration* of the persons riding in it.

Q. *What is the cause of the pretty* FROST-WORK, *seen on bed-room windows in winter time?*

A. The *breath* and insensible *perspiration* of the sleeper (coming in contact with the ice-cold window) are *frozen* by the cold glass; and form those beautiful appearances seen in bed-rooms on a winter's morning.

Q. *Why is the* GLASS *of a window colder than the* WALLS *of a room?*

A. Because glass is so *excellent a radiator*, that it parts with its heat more *rapidly* than the *walls* do.

Q. *Why is a* TUMBLER *of cold* WATER *made quite* DULL *with mist, when brought into a room full of people?*

A. Because the *hot vapour* of the room is *condensed* upon the cold tumbler, with which it comes in contact; and is changed from the invisible and gaseous form, into that of a *thick mist.*

Q. *Why is a* GLASS *made quite* DULL, *by laying a hot hand upon it?*

A. Because the perspiration from the hot hand is *condensed* upon the cold glass, and made perceptible.

Q. *Why are* WINE-GLASSES *made quite* DULL, *when brought into a room full of company?*

A. Because the *hot vapour* of the room (coming in contact with the cold wine-glasses) is condensed upon them, and covers them with moisture, like dew.

Q. *Why does this misty appearance* GO OFF, *after a little time?*

A. Because the glass becomes of the same *temperature*, as the *air* of the room; and will no longer *chill* the *vapour* which touches it, and *condense* it into *mist.*

Q. *Why is a* WINE-BOTTLE *(which has been brought out of a cellar into the* AIR*) covered with a thick* MIST *in summer time?*

A. Because the vapour of the hot air is *condensed* into a thick mist, by contact with the cold glass.

Q. *Why does* BREATHING *on a glass make it quite dull?*

A. Because the vapour of the hot breath is *condensed* by the cold glass, and covers it with a thick mist.

Q. *Why are the walls of a house covered with* WET *in a sudden* THAW?

A. Because they are thick, and cannot *change* their *temperature* so fast as the air; in consequence of which, they *retain* their *cold*, after the thaw has set in

Q. *How does* "RETAINING *their* COLD" *account for their being so wet?*

A. As the vapour of the warm air touches the *cold walls*, it is chilled and *condensed* into *water*; which either *sticks* to the walls, or trickles down in little streams.

Q. *Why does a thick* WELL-BUILT *house contract more* DAMP *of this kind, than an* ORDINARY *one?*

A. Because its walls are much thicker; and (if the frost has penetrated far into the *bricks*) they will be some time before they are reduced to the same *temperature* as the *air*.

Q. *Why are* BALUSTERS, *&c.*, DAMP *after a* THAW?

A. Because they are made of some very close-grained varnished wood, which cannot *change* its *temperature*, so *fast* as the air.

Balusters—corruptly called banisters.

Q. *How does this account for the balusters being* DAMP?

A. Because the vapour of the warm air is chilled by *contact* with the *cold balusters*, and condensed into *water* upon them.

Q. *Why is the* BREATH *visible in* WINTER *and not in* SUMMER?

A. Because the intense cold of winter condenses our breath into *visible vapour;* but in *summer*, the air is *not cold enough* to do so.

Q. *Why is our* HAIR, *and the brim of our* HAT, *often covered with little drops of pearly dew in winter time?*

A. Because our breath is condensed as soon as it comes in contact with our cold hair or hat; and hangs there in little dew-drops.

Q. *Why does the* STEAM *of a railway boiler often pour down, like fine rain, when the steam is "let off?"*

A. Because in cold weather, the steam from the chimney is *condensed* by the *chill air*, and falls like fine rain.

Q. *Why is there* LESS *dew when the wind is* EASTERLY, *than when the wind is* WESTERLY?

A. Because *easterly* winds cross the *continent of Europe*, and (as they pass over *land*) are dry and arid: But *westerly* winds cross the *Atlantic Ocean*, and (as they pass over *water*) are *moist* and full of *vapour*.

Q. *How does the* DRYNESS *of an easterly wind* PREVENT *dew-falls?*

A. As easterly winds are very dry, they *imbibe* the moisture of the air; in consequence of which, there is *very little* left to be condensed into *dew*.

Q. *How does the* MOISTNESS *of a westerly wind* PROMOTE *dew-falls?*

A. As westerly winds are *saturated* with *vapour*, they require very little *eduction of heat* to cause a *copious deposition of dew*.

Q. *When is dew most* COPIOUSLY *deposited?*

A. After a hot day in summer or autumn, especially if the *wind* be westerly

Q. *Why is dew distilled most* COPIOUSLY *after a* HOT *day?*

A. Because the surface of the hot earth *radiates* heat very freely at sun-set;

and (being made much *colder* than the *air*) *chills the passing vapour*, and condenses it into dew.

Q. *Does not* AIR *radiate heat, as well as the* EARTH *and its various plants?*

A. No; the air never *radiates heat;* nor is it made *hot* by the *rays* of the *sun.*

Q. *How is the air made* HOT *or* COLD?

A. By convection of *hot* or *cold currents.*

Q. *Explain this.*

A. Air which is heated by contact with the earth's surface ascends, and colder comes into its place, to be in its turn heated in the same way; this process is repeated, until there no longer remains any cold air to be made warm.

Q. *How is the air made* COLD?

A. By direct contact with the colder earth, and by being mixed with colder currents that are brought by the wind.

Q. *Why is* MEAT *very subject to* TAINT, *if exposed on a clear moon-light night?*

A. Because on a *clear night* it will radiate heat very freely; and, consequently, be *wet* with dew, which favours *rapid* putrefaction.

Q. *How do* MOON-LIGHT *nights conduce to the rapid growth of plants?*

A. Radiation is carried on very rapidly on bright moon-light nights; in consequence of which, *dew* is very plentifully *deposited* on young plants, which conduces much to their growth and vigour.

Q. *Why is evening dew* INJURIOUS *to health?*

A. Because it is always laden with *noxious exhalations* from the earth; especially in *marshy* countries.

Q. *Is* HONEY-DEW *a similar thing to dew?*

A. No. Honey-dew is a sweet liquid, shed by a very small *insect* (called the a'phis), and deposited in autumn on the under surface of favourite leaves.

Frequently on lime trees, in the spring also.

Q. *Does honey-dew* INJURE *leaves, or do them good?*

A. It injures them very much, by filling the *pores* with a thick clammy liquid; in consequence of which, the leaf can neither *transpire*, nor *absorb* its needful food.

Q. *What* EFFECT *has honey-dew upon the appearance of a leaf?*

A. After a little time, the leaf (being *smothered* and *starved*) begins to turn of a *dingy yellow colour.*

Q. *Are not* ANTS *very fond of honey-dew?*

A. Yes; and crawl up to the loftiest trees, in order to obtain it.

Q. *What is the cause of* MIST (*or earth-fog*)?

A. If the *night* has been very *calm*, radiation of heat from the earth has been very abundant; in consequence of which, the *air* (resting on the earth) has been *chilled*, and its vapour condensed into a thick mist.

Q. *Why does not the mist become* DEW?

A. Because the chill of the air is so rapid, that vapour is condensed *faster* than it can be *deposited;* and, (covering the earth in a mist) prevents any further *radiation of heat.*

Q. *When the earth can no longer radiate heat upwards, does it continue to* CONDENSE *the vapour of the air?*

A. No; the air (in contact with the earth) becomes about equal in *temperature* with the surface of the earth itself; for which reason, the mist is not *condensed* into *dew*, but remains *floating* above the *earth* as a thick cloud.

Q. *This mist seems to rise higher and higher, and yet remains quite as dense below as at first. Explain the cause of this.*

A. The air resting on the *earth* is first chilled, and slowly mixing with the air above, condenses it also into mist likewise; and as layer is thus added to layer, the mist seems to be *rising*, when (in fact) it is only *deepening.*

Q. *Why does mist and dew* VANISH, *as the* SUN *rises?*

A. Because the air becomes *warmer* after sun-rise, and *absorbs* the vapour.

Q. *Why is a* DEW-DROP ROUND?

A. Because every part of it is *equally balanced:* and, therefore, there is no cause why *one part* of the drop should be further from the centre, than *another.*

Q. *Why is a* DEW-DROP *(on a broad leaf) sometimes* FLATTENED?

A. Because two or more drops of dew *roll together*, and make one large *spheroid* (or flattened drop.)

Q. *Why will dew-drops* ROLL *about cabbage plants, poppies, &c., without wetting the surface?*

A. Because the leaves of cabbages and poppies are covered with a very *fine waxen powder*, over which the dew-drop rolls without wetting the surface, as a drop of rain over dust.

Q. *Why does not a drop of rain* WET *the* DUST *over which it rolls?*

A. Because dust has no *affinity* for water; and, therefore, repels it.

Q. *Why does not a dew-drop* WET *the* POWDER *of cabbage-plants?*

A. Because the fine powder, which covers cabbage-leaves, has no *affinity* for water; and, therefore, repels it.

Q. *Why will dew-drops* ROLL *over a* ROSE, *&c. without wetting the petals?*

A. Because the leaves of a rose contain an *essential oil*, which has no *affinity* for water; and, therefore, repels it.

Q. *Why can* SWANS *and* DUCKS *dive under water without being* WETTED?

A. Because their feathers are covered with an *oily secretion*, which has no *affinity* for water: and, therefore, repels it

Q. *Why are currents of air from the land* COLDER *than those blowing over water?*

A. Because the earth radiates heat after sun-set more freely than water; consequently, *air* which comes in contact with the land is colder than that which comes in contact with water.

• For other questions respecting land and sea breezes, see Chapter XXII., page 300.

Q. *Why is not air, which passes over water, so* COOL *as that which passes over land?*

A. Because *water* does not cool down at *sun-set*, so fast as *land* does: and, therefore, the air in contact with it remains *warmer*.

Q. *Why does not* WATER *cool down so fast as* LAND?

A. 1st—Because the *surface* of water is perpetually *changing;* and, as fast as one surface is made cold, *another* is presented: and

2ndly—When water is made cold *it sinks*, and *warmer* portions of water *rise* to occupy its place: before, therefere, the *surface* of water is *cooled*, the *whole volume* must be made cold; which is not the case with land.

Q. *What is the cause of a "pea-soup"* LONDON FOG?

A. These fogs (which occur generally in the winter time) are occasioned thus:—Some current of air (being suddenly cooled) *descends* into the *warm streets*, forcing back the smoke in a *mass* towards the earth.

Q. *Why are there not* ALWAYS *fogs, every night?*

A. Because the air will always hold in solution a certain quantity of vapour, (which varies according to its temperature); and, when the air is not *saturated*, it may be cooled without parting with its vapour.

Q. *When do fogs occur at night?*

A. When the air is *saturated with vapour* during the day. When this is the case, it deposits some of its superabundant moisture in the form of dew or fog, as soon as its capacity for holding vapour is lessened by the *cold night.*

Q. *Why is there very often a fog over* MARSHES *and* RIVERS, *at night-time?*

A. Because the air of marshes is

almost always near *saturation;* and, therefore, the least depression of *temperature* will compel it to relinquish some of its moisture in the form of dew or fog.

Q. *What is the* DIFFERENCE *between dew and rain?*

A. In *dew*, the condensation is made near the *earth's surface.*

In *rain*, the drops fall from a considerable height.

Q. *What is the* CAUSE *of both dew and rain?*

A. Cold *condensing* the vapour of the *air*, when near the point of *saturation.*

Q. *Why do mist and fog* VANISH *at sun-rise?*

A. Because the condensed particles are again *changed* into *invisible* vapour by the heat of the sun.

Q. *What is the difference between a* MIST *and a* FOG?*

A. MIST is generally applied to *vapours* condensed on *marshes*, *rivers*, and *lakes.*

FOG is generally applied to *vapours*

condensed on *land;* especially if those vapours are laden with smoke.

Q. *What is the reason why condensed vapour sometimes forms into* CLOUDS, *and sometimes into* FOG?

A. If the surface of the EARTH is hotter than the incumbent *air*, the vapour of the earth is *chilled* by the *cold air*, and becomes FOG: But if the AIR is hotter than the *earth*, the vapour *rises through the air*, and becomes CLOUD.

Q. *If cold air produces fog, why is it not foggy on a* FROSTY MORNING?

A. 1st—Because *less vapour* is formed on a *frosty day:* and

2ndly—The vapour is *frozen* upon the *ground*, before it can rise from the earth; and becomes HOAR-FROST.

Q. *Why are fogs more general in* AUTUMN *than in spring?*

A. 1st—Because the air in spring is generally much *drier* than in autumn; in consequence of which, it is not so near the point of *saturation:* and

2ndly—The *earth* in spring is not so *hot*. as it is in autumn; in consequence of which its vapour is not chilled into fog, as it rises into the air.

Q. *Why are fogs more common in* VALLEYS, *than on hills?*

A. 1st — Because valleys contain more *moisture* than hills; and

2ndly — They are *not exposed* to sufficient *wind*, to dissipate the vapour.

Q. *How does* WIND *dissipate fogs?*

A. Either by *blowing* them away; or else by *dissolving* them into *vapour* again.

Q. *What is* HOAR-FROST?

A. There are two sorts of hoar-frost: 1.—FROZEN DEW: and 2.—FROZEN FOG

Q. *What is the cause of the* GROUND *hoar-frost, or frozen dew?*

A. Very *rapid* radiation of heat from the earth; in consequence of which, the *surface* is so *cooled* down, that it *freezes* the dew condensed upon it.

Q. *Why is hoar-frost seen only after a very* CLEAR *night?*

A. Because the earth will not have thrown off heat enough by radiation, to *freeze* the vapour condensed upon its surface, unless the night has been very clear indeed.

Q. *Why does hoar-frost very often cover the* GROUND *and* TREES, *when the water of rivers is not frozen?*

A. Because it is not the effect of cold in the *air*, but cold on the surface of the *earth* (produced by excessive radiation), which *freezes dew* into hoar-frost.

Q. *Why is the hoar-frost upon* GRASS *and* VEGETABLES *much thicker than that upon lofty trees?*

A. Because the air (resting on the *surface* of the ground) is much colder after sun-set, than the air *higher* up: in consequence of which, more *vapour* is *condensed* and *frozen* there.

Q. *Why is the* AIR *(resting on the surface of the earth) colder than that in the* HIGHER *regions?*

A. Because the *earth* radiates more heat than the *leaves* of lofty trees; and, therefore, more *rapidly condenses* and *freezes* the vapour of the air.

Q. *Why are evergreens often* FROST-BITTEN, *when lofty trees are* NOT?

A. Because they do not rise far above

the surface of the earth; and (as the air *contiguous* to the earth is made *colder* by radiation, than that in the *higher* regions) therefore, the *low evergreen* is often *frost-bitten*, when the lofty tree is uninjured.

Q. *Why is there little or no hoar-frost under* SHRUBS *and shady* TREES?

A. 1st—Because the leafy top *arrests* the process of radiation from the earth.

2ndly—Shrubs and trees radiate *heat* towards the earth; and, therefore, the *ground beneath* is never *cold enough* to *congeal* the little dew deposited there.

Q. *Why is there more* HOAR-FROST *along the shady margin of a* HEDGE *than in the open field, as the day advances?*

A. 1st—Because the shade of the hedge prevents the dissipation of the *hoar-frost* by the *sun:* and

2ndly—Because the hedge screens off wind and prevents the *repose of the air* being disturbed.

Q. *What is the cause of that hoar-frost, which arises from* FROZEN FOG?

A. The congelation of night-fog by

the freezing chill of *early* morning, in consequence of which the fog is frozen upon every object on which it was deposited.

CHAPTER XVII.

5.—CONVECTION.

Q. *What is meant by the* CONVECTION *of heat?*

A. Heat communicated by being *carried* to another thing or place; as the hot water rising from the *bottom* of a kettle, carries heat upward in its ascent. (*see p.* 252.)

Q. *Are liquids good* CONDUCTORS *of heat?*

A. No; liquids are bad *conductors*; and are, therefore, made hot by *convection.*

Q. *Why are liquids bad conductors of heat?*

A. Because their particles (upon every change of temperature) are put into *motion*, and do not remain sufficiently long in contact with each other to conduct heat progressively, like a bar of iron.

When heat is applied to the surface of a fluid, it is very *slowly* diffused in a downward direction, because the warmed particles continually ascend, without having time to impart heat to the particles below.

Q. *Explain how water is made* HOT.

A. The water *nearest the fire* is *first* heated, and (being heated) *rises* to the *top;* its place is supplied by *colder* portions, which are heated in turn, and this interchange continues till *all* the water is boiling hot.

Q. *Why is water in such continual* FERMENT, *when it is* BOILING?

A. This commotion is mainly produced by the *ascending* and *descending* currents of hot and cold water.

The escape of steam from the water contributes to increase this agitation.

Q. *How do these two currents* PASS *each other?*

A. The hot *ascending* current rises up through the *centre* of the mass of water; while the cold descending currents pass down by the metal sides of the kettle.

For other questions upon the subject of boiling water, see from page 115 to 222.

Q. *Why is heat applied to the* BOTTOM, *and not to the top of the kettle?*

A. Because the heated water always *ascends* to the *surface;* if, therefore, heat were applied to the *top* of a vessel, the water below *the surface* would never be *heated.*

Q. *As the lower part of a grate is made* RED-HOT *by the fire above, why would not water boil if fire were applied to the* TOP *of a kettle?*

A. The *iron* of a grate is an excellent *conductor;* if, therefore, *one* part be heated, the heat is conducted to *every* other part: But *water* is a very *bad conductor*, and will not diffuse heat in a similar way.

Q. *Prove that water is a* BAD *conductor of heat.*

A. When a blacksmith immerses his red-hot iron in a tank of water, the water which surrounds the iron is made *boiling hot*, while that *below the surface* remains quite cold.

Q. *If you wish to cool liquids, where should the cold be applied?*

A. To the *top* of the *liquid:* because the *cold* portions will always *descend*, and allow the warmer parts to come in contact with the cooling substance.

Q. *Does* BOILING *water get hotter by being* KEPT *on the fire?*

A. No:—not if the steam be suffered to escape.

Q. *Why does not boiling water get* HOTTER *if the steam be suffered to escape?*

A. Because the *water* is converted into *steam*, as fast as it boils; and the steam *carries away* the additional heat.

Q. *Why does* SOUP *keep hot longer than boiling water?*

A. Because the grease and various ingredients floating in the soup, retard the ascent of the hot particles, and prevent their rising so freely to the surface.

Q. *If you want to keep water* HOT *for a long time, how could it be done?*

A. By adding a little *starch* or flour to the water.

Q. *Why would a little* STARCH, *added to boiling water, serve to keep it hot?*

A. Because it would retard the ascent of the hot particles, and prevent their reaching the surface of the water.

Q. *Why do thick milk, rice milk, &c., remain* HOT *longer than water?*

A. Because the ascent of the hot

particles is opposed by the flour or rice, which therefore cannot reach the surface so quickly.

Q. *Is* STEAM *visible or invisible?*

A. Steam is *invisible;* but when it comes in contact with the air, and is *condensed* into small drops, it becomes visible.

Q. *How do you know that steam is* INVISIBLE?

A. If you look at the spout of a boiling kettle, you will find that the steam (which issues from the spout) is always invisible for about *half an inch;* after which, it becomes *visible.*

Q. *Why is the steam invisible for half an inch?*

A. Because the air is not able to condense it, as it first issues from the spout; but when it *spreads* and comes in contact with a larger volume of air, the *invisible steam* is readily condensed into *visible drops.*

Q. *Why do steam-engines sometimes burst?*

A. Because steam is very *elastic;* and this elasticity increases in a greater proportion than the heat which produces it: unless, therefore, some *vent* be freely allowed, steam will burst the vessel which confines it.

Q. *Is air a good* CONDUCTOR?

A. No: *air* is a very *bad conductor*; and is heated (like water) by *convection*.

Q. *How is a room warmed by a* STOVE?

A. The air *nearest* the fire is made hot *first*, and rises; *cold air* then *descends*, is heated, and *ascends* in like manner; and this interchange goes on, till *all* the air of the room is *warmed*.

Q. *Why are fires placed on the* FLOOR *of a room?*

A. Because heated air always *ascends*. If, therefore, the fire were not near the *floor*, the air of the *lower* part of the room would never be heated by the fire at all.

Q. *If you take a poker out of a fire, and hold the hot end* DOWNWARDS, *why is your hand scorched with heat?*

A. Because the hot end of the poker *heats the air* around it; and this hot air (in its ascent) *scorches* our *hand*.

Q. *How should a* RED-HOT *poker be carried, so as not to burn our fingers?*

A. With the hot end *upwards*; for then the air (heated by the poker) would not pass over our hand and scorch it.

PART II.

AIR.

CHAPTER XVII.

Q. *Of what is atmospheric* AIR *composed?*

A. Principally of two gases, *oxygen* and *nitrogen;* mixed together in the following proportion: viz. one gallon of oxygen, to four of nitrogen.

It must not be forgotten that the air contains small quantities of other gaseous substances also, as *vapour of water*, *carbonic acid* and *ammonia.*

Q. *What do you mean by a* GAS?

A. A permanent *elastic* fluid, resembling air.

N.B.—MOST GASES ARE INVISIBLE AND TRANSPARENT, LIKE AIR.

"PERMANENT."—In this respect gas differs from *vapour* which is *not* permanent: for vapour may be easily condensed by cold into a liquid, but gas does not change its gaseous form under ordinary pressure.

"ELASTIC."—In this respect gas differs from a liquid, which is almost inelastic; whereas gas is exceedingly elastic.

"RESEMBLING AIR" or aeriform.—The word "Gas" means *air*, but air is a compound of two gases. Some few gases are visible, as *chlorine*, which is a greenish yellow.

Q. *What is the difference between a* GAS *and a* LIQUID?

A. Gases are *elastic*, but liquids *not.*

Q. *Illustrate what is meant by "the* ELASTICITY *of gas."*

A. If from a vessel full of gas, *half* were taken out—the *other* half would immediately spread itself out, and fill the same space, as was occupied by the original quantity.

Q. *Prove that a liquid is* NOT ELASTIC.

A. If from a gallon of water you take *half*, the remaining 4 pints will take up only *half* the room that the whole gallon previously did: a *liquid*, therefore, is not elastic, like *gas.*

Strictly speaking, a liquid is slightly elastic; inasmuch as it may be *compressed*, and will afterwards recover its former dimensions.

Q. *What are the chief uses of the* OXYGEN *of the air?*

A. To *support* combustion, and *sustain* life.*

Q. *What is meant, when it is said, that the oxygen of the air "*SUPPORTS COMBUSTION?*"*

A. It means this: It is the *oxygen* of the air, which makes *fuel burn.*

Q. *How does the* OXYGEN *of the air make* FUEL BURN?

A. The fuel is decomposed (by heat) into *hydrogen* and *carbon;* and these elements, combining with the *oxygen* of the air, produce combustion.

Q. *What* GAS *is produced by the combination of carbon and oxygen?*

A. CARBONIC ACID GAS. (*See p.* 38.)

Q. *What becomes of the* HYDROGEN *of the* FUEL?

A. The *hydrogen* of the fuel combines with the *oxygen* of the air, and forms WATERY VAPOUR; but the combination is attended by the production of *flame*, owing to the very inflammable nature of hydrogen.

It must be remembered, that the gas of burning fuel is *not pure*, but *carburetted* hydrogen.

Q. *What becomes of the* NITROGEN *of the air, amidst all these changes and combinations?*

A. The nitrogen escapes *unchanged* to be again mixed with *oxygen*, and converted into common AIR.

Q. *What is meant, when it is said, that oxygen* "SUSTAINS LIFE?"

A. It means this: If a person *could not inhale oxygen*, he would *die.*

Q. *What* GOOD *does this inspiration of oxygen do?*

A. 1st—It gives *vitality* to the *blood*; and

2ndly—Is the *cause* of *animal heat.*

Q. *How is food converted into* BLOOD?

A. After it is swallowed, it is dissolved in the stomach into a *grey pulp*, called CHYME; it then passes into the intestines and is converted by the "bile" into a *milky substance*, called CHYLE.

Chyme, *pronounce* kyme; chyle, *pronounce* kyle; *each as one syllable.*

Q. *What* BECOMES *of the milky substance called* CHYLE?

A. It is absorbed by the vessels called "*lacteals*," and poured into the veins on the *left side* of the *neck.*

"Lacteals," *pronounce* lac-te-als.

Q. *What becomes of the chyle,* AFTER *it is poured into the veins?*

A. It *mingles* with the *blood*, and is itself *converted* into blood also.

Q. *How does the oxygen we inhale,* MINGLE *with the blood?*

A. The oxygen of the air mingles with the blood in the *lungs*, and converts it into a *bright red colour*

Q. *What colour is the blood* BEFORE *it is oxidized in the lungs?*

A. *A dark purple.* The oxygen turns it to a *bright red.*

Oxidized, i.e., impregnated with oxygen.

Q. *Why are persons so* PALE, *who live in rooms and cities?*

A. Because the air in close rooms and cities is not *fresh;* and being *deficient* in *oxygen*, cannot turn the blood to a beautiful bright red.

Q. *Why are persons who live in the open air and in the country, of a* RUDDY *complexion?*

A. Because they inhale fresh air, which has its full proportion of oxygen: and the blood derives its bright red colour from the *oxygen* of the air inhaled.

Q. *Why is not the air in* CITIES *so* FRESH, *as that in the* COUNTRY?

A. Because it is impregnated with the *breath* of its numerous inhabitants, the *odour* of its sewers, the *smoke* of its fires, and many other impurities.

Q. *How does oxygen convert the colour of blood into a bright* RED?

A. The *colouring* matter of the blood

is formed of very minute *globules*, floating in it; the oxygen (uniting with the *coats* of these *globules*) makes them *milky*—and the dark colouring matter of the blood (seen through this *milky coat*) appears of a *bright red*.

Exp.: If you put some dark *venous* blood into a *milky* glass, and hold it up towards the light, it will appear of a *bright florid* colour, like *arterial* blood.

Q. *How does the combination of oxygen with the blood produce animal* HEAT?

A. The principal element of the blood is *carbon;* and this carbon (combining with the oxygen of air inhaled) produces *carbonic acid gas*, in the same way as burning fuel. (*See p.* 39.)

Q. *What becomes of the* NITROGEN *of the air after the oxygen enters the blood?*

A It is thrown out from the lungs unchanged, by the act of breathing; to be again mixed with *oxygen*, and converted into common AIR.

Q. *Why does the vitiated air* (*after the oxygen has been absorbed*) COME OUT *of the* MOUTH, *and not sink into the stomach?*

A. Because it is driven out by the

contraction of the walls of the chest, and there is no vacant space in the cavity of the gullet and stomach for it to fall into.

N.B.—The lungs are a *hollow spongy mass*, capable of holding air, and of being *dilated*. They are so situated in the thorax (or chest), that the air *must* enter into them, whenever the cavities of the thorax are enlarged. The process of breathing is performed thus: When we INHALE, the thorax (or chest) is expanded; in consequence of which, a *vacuum is formed round the lungs*, and heavy external air instantly enters (through the mouth and throat), to *supply* this vacuum.

When we EXHALE, the thorax *contracts* again; in consequence of which, it can no longer contain the *same quantity* of air, as it did before; and some of it is necessarily *expelled*. When this expulsion of air takes place, the *muscular fibres*, which form the floor of the chest, *contract*, in order to assist the process.

Q. *If (both in combustion and respiration) the* OXYGEN *of the air is* CONSUMED, *and the* NITROGEN REJECTED—*Why are not the* PROPORTIONS *of the air* DESTROYED?

A. Because the *under surface of vegetable leaves* (during the day) gives out *oxygen;* and thus restores to the air the very element of which it has been deprived.

Q. *Whence do leaves* OBTAIN *the oxygen, which they exhale?*

A. From the *carbonic acid*, absorbed by the *roots* from the soil, and carried to the leaves by the rising *sap*.

N.B.—Carbonic acid (it must be remembered) is a compound of carbon and oxygen.

Q. How *do plants contrive to absorb carbonic acid from the soil?*

A. It rises (by capillary attraction) through the small fibrous roots, after it has been dissolved in the soil by water.

Q. *Whence does the* SOIL *obtain carbonic acid?*

A. 1st—From the air; from which it is driven by falling showers:

2ndly—From the decomposition of vegetable and animal matters, which always produces this gas in abundance: and

3rdly—All lime-stone, chalk, and calcareous stones, contain vast quantities of carbonic acid in a *solid* state, and the presence of any acid sets it free.

Calcareous, i.e. of a limy nature.

Q. *If leaves throw off the* OXYGEN *of the carbonic acid, what becomes of the carbon?*

A. It is retained to give *firmness* and *solidity* to the plant itself.

Q. *Show how God has made* ANIMAL *life dependent on that of* VEGETABLES.

A. *Animals* require *oxygen* to keep them alive, and *draw it from the air* by inspiration: The under surface of *leaves* *gives out oxygen;* and thus supplies the air with the *very gas* required for the use of animals.

Q. *Show how God has made* VEGETABLE *life dependent on that of animals.*

A. Plants require *carbonic acid,* which is their *principal food;* and all animals exhale this gas from their lungs. Thus *animals* supply plants with *carbonic acid,* and plants supply animals with *oxygen.*

Q. *How is air* HEATED?

A. By "convective currents."

Q. *Explain what is meant by* "CONVECTIVE CURRENTS."

A. When a portion of air is heated, it *rises upwards in a current,* carrying heat with it: other *colder air succeeds,* and (being *heated* in a similar way) *ascends* also: and these are called "convective currents."

"Convective currents"—so called from the Latin words, *cumvectus* (carried with); because the *heat* is "carried with" the current.

Q. *Is air heated by the rays of the* SUN?

A. No; air is *not heated* (in any sensible degree) by the action of the *sun's rays* passing through it

Q. *Why is the air* HOTTER *on a* SUNNY *day, than on a* CLOUDY *one?*

A. Because the sun heats the *surface* of the *earth*, and the air (resting on the earth) is *heated by contact:* as soon as it is heated *it ascends*, and its place is supplied by *colder* portions, which are heated in turn also.

Q. *If air be a* BAD *conductor, why does hot iron become cold, by exposure to the* AIR?

A. Because it is made cold; 1st—By "convection;" and 2ndly—By "radiation."

Q. *How is hot iron made cold by* CONVECTION?

A. The air resting on the hot iron (being intensely heated) rapidly ascends with the heat it has absorbed; *colder* air succeeding *absorbs more heat*, and ascends also; and this process is repeated, till the hot iron is completely *cooled down.*

Q. *How is hot iron cooled by* RADIATION?

A. While its heat is being carried off by "convection," the hot iron *throws off heat* (on all sides) *by radiation* also.

Q. *What is meant by* RADIATION?

A. The throwing off of heat (in all directions) from the surface of a hot body.

Radiation.—It was once thought that heat was emitted from hot bodies in the form of rays.

Q. *How is soup* COOLED *by being left exposed to the* AIR?

A. It throws off *some* heat by *radiation;* but it is mainly cooled down by *convection.*

Q. *How is hot soup cooled down by* CONVECTION?

A. The air *resting* on the *hot soup* (being heated) *ascends; colder* air succeeding *absorbs more heat;* and *ascends also;* and this process is repeated, till the soup is made *cool.*

The particles on the surface of the broth *sink* as they are cooled down, and *warmer* particles rise to the surface; which greatly assists the cooling process.

Q. *Why are hot tea and soups* COOLED *the faster for being stirred about?*

A. 1st—Because agitation assists in bringing the hottest particles to the *surface:*

2ndly—The action of stirring *agitates* the air, and brings it more *quickly* to the soup or tea: and

3rdly—As the hotter particles are more rapidly brought into contact with the air, convection is *more rapid.*

Blowing tea or broth cools it also. (*See p.* 186.)

Q. *If a shutter be closed in the day-time, the stream of light (piercing through the crevice) seems in* CONSTANT *agitation.* WHY *is this?*

A. Because little *motes* and *particles of dust* (thrown into agitation by the *convective currents* of the air) are made *visible* by the strong beam of light, thrown into the room through the crevice of the shutter.

Q. *Why can we not* SEE *the air?*

A. Because it is perfectly transparent, i. e. permits all the rays of light to pass through it without reflecting any.

Q. *Why does water* RISE *in a common pump?*

A. Because the *pressure* of the *air* is removed from the water in the *pipe of the pump* by the action of the *sucker;* but not from the water in the well.

Take a tube (shaped like a U) partially filled with water, and let an equal weight be fitted to each orifice: so long as the weights are undisturbed, the water will remain at the same level on both sides of the tube: but if one weight be removed, its place will be instantly occupied with an equal weight of water. So in a pump, the air may be compared to these two weights; as the action of the sucker removes *one,* water rushes into the pipe to counterbalance the weight of air pressing on the water in the well.

Q. *How high can atmospheric* PRESSURE *make water rise in a pipe of a pump?*

A. About 30 feet above the level of the water in the well.

It would be nearly 34 feet if the pump were of perfect construction. Because a column of water 34 feet high, weighs the same as an equal-size column of air, reaching to the top of the atmosphere. N.B.—The atmospheric pressure is 15 pounds on each square inch.

Q. *How is water* PUMPED *from a well more than* 30 *feet deep?*

A. The piston-rod is made to extend within 30 feet of the water in the well; and when the water has risen thus high, it passes through a valve in the sucker, and is *lifted* out of the pump by the piston box.

The water is *lifted* from deep wells, and never *sucked* up beyond 30 feet.

Q. *Why does a syphon* EMPTY *a vessel of its liquid?*

A. Because one side of the bent tube being *longer* than the other, contains a *greater weight* of water, and the *balance* is destroyed.

The unequal weight of water in the two tubes, causes the water of the longer tube to fall out and produce a vacuum. In a common PUMP the vacuum is produced by the mechanical action of the sucker.

Q. *Why is it often difficult and painful to breathe on a mountain top?*

A. Because the *pressure* of the air on a mountain top is not so great as on a plain. Consequently the fluids in the body *expand*, and painfully *stretch* the membranes which contain them.

Q. *Why do we often feel* OPPRESSED *just previous to a storm?*

A. Because the air is greatly rarefied; and the *removal* of *pressure* from the surface of the body, causes a painful distension.

Q. *How do you know that the density of the air is lowered, previous to a storm?*

A. Because the *mercury* of a barometer rapidly *falls*.

The mercury in the tube of the barometer is held up, like the water in the tube of the pump, by the pressure of the atmosphere.

Q. *Why do* CORNS *ache previously to* RAIN?

A. Because the rarefied state of the air causes *distension* in the tissues of the feet; and as the *hard corn* cannot swell equally with the *softer parts*, irritation is produced in the fibrils of the nerves.

Q. *Why do* CELLARS *feel* WARM *in* WINTER?

A. Because the external air has not

free access into them; in consequence of which, they remain almost at an *even temperature;*—which (in winter time) is about ten degrees *warmer* than the external air.

Q. *Why do* CELLARS *feel* COLD *in* SUMMER?

A. Because the external air has not free access into them; in consequence of which, they remain almost at an *even* temperature,—which (in summer time) is about ten degrees *colder* than the external air.

Q. *Why does* AIR *rust* IRON?

A. Because the *oxygen of the air* combines with the *surface* of the metal, and produces *oxide of iron:* which is generally called "rust."

An oxide of iron, copper, &c., is oxygen in *combination* with iron, copper, &c.

Q. *Why does hot iron* SCALE *and* PEEL *off when struck with a* HAMMER?

A. Because the *oxygen of the air* very readily unites with the surface of *hot iron*, and forms a metallic oxide (or rust), which scales off, when struck with a hammer.

Q. *Does iron* RUST *in* DRY *air?*

A. No; iron undergoes no change in dry air.

Q. *Why do* STOVES *and* FIRE-IRONS *become* RUSTY *in rooms, which are not* OCCUPIED?

A. Because the air is damp; and moist air *oxidizes* iron and steel.

Oxidizes, i.e. rusts.

Q. *In what part of the year is it most difficult to keep* STOVES *and* FIRE-IRONS BRIGHT?

A. In *autumn* and *winter.*

Q. *Why is it more difficult to keep* STOVES *and* FIRE-IRONS *bright in autumn and winter, than in spring and summer?*

A. Because the capacity of the air for holding water is constantly on the *decrease*, after the summer is over; in consequence of which, vapour is deposited on everything with which the air comes in contact.

Q. *Why does* GREASING *iron prevent its becoming* RUSTY?

A. Because *grease* prevents the humidity of air from coming in contact with the *surface* of the *iron.*

Q. *Why do not stoves rust, so frequently as* POKERS *and* TONGS?

A. Because stoves are generally covered with *plumbago*, or black lead.

Q. *What is plumbago or black lead?*

A. A mixture of charcoal and iron.

Plumbago (strictly speaking) is a chemical union of *carbon* and *iron*), in the following proportions :—91 parts carbon and 9 iron. But the BLACK LEAD sold in shops is a mixture of charcoal and iron filings.

N.B.—A most excellent varnish to prevent rust is made of 1 pint of fat oil varnish, mixed with 5 pints of highly rectified spirits of turpentine, rubbed on the iron or steel with a piece of sponge. This varnish may be applied to bright stoves, and even mathematical instruments, without injuring their delicate polish.

Q. *Why does ornamental* STEEL *(of a purple or* LILAC *colour) rust more readily, than polished* WHITE *steel?*

A. Because the lilac tinge is produced by *partial oxidation;* and the process which forms rust has already commenced.

Q. *How can lilac* STEEL *be kept* FREE *from* RUST?

A. By keeping it in a *dry place.*

Q. *If* DRY AIR *contains* OXYGEN, *why does it* NOT RUST IRON, *as well as moist air?*

A. Because moisture is necessary to bring into action the affinity of oxygen for steel.

Water is decomposed by contact with iron; but it is chiefly the *oxygen* of water which *rusts* iron. Even DRY air oxidizes iron at a high temperature; thus a red-hot poker is rusty, when it cools.

Q *Do any* OTHER *metals (besides iron) combine rapidly with oxygen?*

A. Yes; copper, zinc, lead, mercury; and even silver oxidizes to some extent.

Q. *Why do* COPPER *and* ZINC *tarnish?*

A. The tarnish of copper and zinc is caused by their *oxidation;* that is, oxygen from the moist air combines with the surface of the metals, and (instead of *rusting them*) covers them with a *dark tarnish.*

Q. *Why does* LEAD *become of a* DARKER *hue, by being exposed to the air?*

A. Because the oxygen of the moist air combines with the lead, and *oxidizes its surface;* which instead of becoming *rusty*, assumes a *darker hue.*

Q. *Why does lead lose its brightness, and become* DULL, *by being exposed to the air?*

A. The *dullness* of the lead is caused by the presence of a *carbonate* of the oxide: When the oxide is formed, it attracts *carbonic acid* from the air, and by combining with it, produces a *carbonate*, which gives the *dull* tint to old lead.

Q. *Why is it difficult to keep silver* BRIGHT?

A. Because the vapour of the air oxidizes its surface, and *tarnishes it*

The tarnish of silver forks and spoons, is often due to the sulphur and sulphuretted hydrogen of certain foods united to the silver by saliva, according to a regular galvanic process. N B.—Without saliva, egg spoons, &c., will not tarnish from food, because the galvanic influence is not brought into action.

Q *Why do silver* TEA-POTS *and* SPOONS *tarnish more quickly than silver ore or bullion ?*

A. Because alloy of some *baser* metal is used, to make them more *hard and lasting;* and this *alloy* oxidizes more quickly, than silver itself.

Q. *Why does* GERMAN *silver turn a dingy yellow in a few hours ?*

A. Because German silver has a great affinity for oxygen ; and shows its oxidation by a *yellow tarnish*, instead of rust.

Q. *If quicksilver (or mercury) will tarnish like copper and lead—why does it preserve its brilliancy in* BAROMETERS *and* THERMOMETERS ?

A. Because the *air* is excluded ; and no moisture can come in contact with it, to *oxidize* (or *tarnish*) it.

Q. *Is* GOLD *affected by the atmosphere ?*

A. Not readily ; gold will never combine with oxygen of itself, (i. e. without aid).

Q. WHICH *of the metals is capable of resisting oxidation altogether ?*

A. Plat'inum ; in consequence of

which, the graduated arcs of delicate "instruments for observation" are made of plat'inum, in preference to *other* metals.

Before plat'inum was known, gold was used for this purpose.

Q. *Why is* PLAT'INUM *used for the graduated arcs of delicate mathematical instruments, instead of any other metal?*

A. Because it will never oxidize; but retains its *bright surface* in all weathers, free from both *rust* and *tarnish.*

"Platinum," (a white metal,) so called from "plata," the Spanish word for *silver*. It was introduced from South America into England by Mr. Wood. (A.D. 1749.)

Q. *For what other* SCIENTIFIC *purpose is* PLATI'NUM *now used?*

A. For the construction of crucibles in which *acids* are to be employed; and for the formation of some of the plates for galvanic batteries.

Q. *Why are* CRUCIBLES (*in which acids are employed*) *made of* PLAT'INUM?

A. Because the acid would act upon *other metals*, or upon *glass;* and prevent the experimenter's success.

Q. *Which of the* METALS *have the greatest affinity for* OXYGEN?

A. Those called *potas'sium* and *so'dium.*

Potas'sium and so'dium derive their names from potash and soda. Potas'sa is the oxide of potas'sium; and soda is the oxide of so'dium.

Q. *How is the affinity of potas'sium and so'dium for oxygen shewn?*

A. They *decompose water* immediately they are brought into contact with it.

Q. *What effect has* POTASSIUM *on water?*

A. It *decomposes* it. The hydrogen being set free, combines with the oxygen of the air, and is ignited by the latent heat liberated from the potassium.

N.B.—Water is composed of oxygen and hydrogen; Potassium *separates* these two gases.

Q. *What effect has* SODIUM *on water?*

A. It does not produce *flame*, as potassium does; but it decomposes water and undergoes very rapid *oxidation.*

Q. *Is the* FURR *of* KETTLES *an oxide?*

A. No; the furr (or deposit of boiling water) is a precipitate of *lime and mineral salt*, separated from water by the process of boiling.

Q. *Is not the* FURR *of boiling water often* DANGEROUS?

A. Yes; especially in *tubular boilers*, such as those employed in railways.

Q. *Why is* FURR *especially troublesome in* RAILWAY *engines?*

A. Because it is a *bad conductor* of heat: in consequence of which, it hinders the process of *evaporation;* and as more fuel is required to produce the needful amount of steam, a great waste of fuel is incurred.

Q. *Why is* FURR *especially* DANGEROUS *in* RAILWAY *engines?*

A. Because the boilers are likely to become *over-heated,* when furr is deposited in them, as the water is no longer in immediate contact with the metal itself: When this is the case, *explosion* may occur from the sudden generation of highly elastic steam.

Q. *Why are* RAILWAY *engines never fed with* BRACKISH *water?*

A. Because *brackish* water contains much *mineral matter;* which causes a large deposit of furr.

Furr may be removed from kettles by boiling in them a little sal-ammoniac (*hydrochlorate of ammonia*). The hydrochloric acid unites with the lime of the furr, and the carbonic goes to the ammonia. Both of these new compounds dissolve, and wash away most easily

CHAPTER XIX.

CARBONIC ACID GAS.

Q. *What is* CARBONIC ACID *gas?*

A. A gas formed by the union of *carbon* and *oxygen:* It used to be called "FIXED AIR."

3 lbs. of carbon and 8 lbs. of oxygen will form 11 lbs. of carbonic acid. It may be obtained and collected in the usual way, by pouring a mixture of one part of muriatic acid, and 10 of water, on pounded marble contained in a retort.

Q. *Under what circumstance does* CARBON *most readily unite with* OXYGEN?

A. 1st—When its *temperature* is *raised:* Thus if carbon be *red* hot, oxygen will most readily unite with it: and

2ndly—When it forms part of the fluid *blood.*

Q. *Why do oxygen and carbon so readily unite in the* BLOOD?

A. Because the atoms of carbon are *so loosely attracted* by the *other* materials of the blood, that they unite very readily with the oxygen of the air inhaled

Q. *Is carbonic acid* WHOLESOME?

A. No; it is *fatal to animal life;* and (whenever inhaled) acts like a narcotic poison, producing drowsiness, which sometimes ends in death.

Q. *How can any one* KNOW, *if a place be infested with* CARBONIC ACID *gas?*

A. If a pit or well contain carbonic acid, a *candle* (let down into it) will be *instantly extinguished.* The rule, therefore, is this—Where a *candle will burn,* a *man can live;* but what will *extinguish* a candle, will also *destroy* life.

Q. *Why does a* MINER *lower a* CANDLE *to the bottom of a mine, before he descends?*

A. Because a candle will be *extinguished,* if the mine contain carbonic acid gas: but if the candle be *not* extinguished, a man may fearlessly descend.

Q. *Why do well-sinkers often let down buckets of fresh-slacked* LIME *in wells, before they descend?*

A. Because if carbonic acid be present, the lime will absorb it to form carbonate of lime.

Q. *Why does a* CROWDED ROOM *produce* HEAD-ACHE?

A. Because its air is *vitiated* by the action of many human lungs.

Q. *Why is the air of a room* VITIATED *by a* CROWD?

A. Because it is deprived of its due proportion of *oxygen*, and laden with *carbonic acid.*

Q. How *is the air of a room vitiated by a crowd?*

A. The *elements* of the air inhaled are *separated* in the *lungs:* A part of the oxygen is converted in the blood into carbonic acid: and then thrown back again with the breath into the room.

Q. *Why are sailors occasionally killed when sent to examine the well of a ship?*

A. Because it contains *carbonic acid*, probably given off from some part of the cargo, in consequence of its fermentation. This gas remains in the lowest hollows of the hull, in consequence of its great weight.

Cargoes of rice and coffee sometimes get damp from leakage, and then ferment and throw off vast quantities of carbonic acid. March 1, 1817, four men were killed in the trading ship, Gryb Hawoody, on its voyage from Calcutta, in consequence of being sent to examine the well containing carbonic acid, given off from some damp rice.

Q. *Mention the historical circumstances, so well known in connection with the* "BLACK HOLE" *of Calcutta.*

A. In the reign of George II., the

Raja (or Prince) of Bengal marched suddenly to Calcutta, to drive the English from the country; as the attack was unexpected, the English were obliged to submit, and 146 persons were taken prisoners.

The Sur Raja, at Dowlat; a young man of violent passions, who had but just succeeded to the throne. A.D. 1756.

Q. *What became of these prisoners?*

A. They were driven into a place about 18 feet square, and 15 or 16 feet in height, with only two small grated windows. 123 died in one night; and (of the 23 who survived) the larger portion died of putrid fevers after they were liberated.

Q. *Why were* 123 *persons* SUFFOCATED *in a few hours, from confinement in this close hot* PRISON-*hole?*

A. Because the *oxygen* of the air was soon *consumed* by so many lungs, and its place supplied by *carbonic acid*, exhaled with the hot breath.

Q. *Why did the captives in the* BLACK HOLE *die* SLEEPING?

A. 1st—Because the *absence of oxy-*

gen quickly affects the vital functions, depresses the nervous energies, and produces great lassitude: and

2ndly—*Carbonic acid* (being a narcotic poison) produces *drowsiness* in those who inhale it, before it kills them.

The floor of the Grotto del Canè, in Italy (i.e. Cavern of Dogs) is always laden with carbonic acid. It is a common practice with the guides who shew it, to drive dogs in, and cause them to suffer a temporary death. A man may safely enter the cavern, because his mouth reaches far above the noxious gas, which, being nearly twice as heavy as air, settles on the bottom of the cave.

The Lake Averno, which Virgil supposed to be the entrance to the infernal regions, gives out so much of this gas, that birds, flying over it, are suffocated. Lake Averno means, *the lake destructive to birds.*

Q. *Why are the* JUNGLES *of Java and Hindostan so* FATAL *to life?*

A. Because vast quantities of *carbonic acid* are thrown off by decaying *vegetables* in these jungles; and (as the wind cannot penetrate the thick brushwood, to blow the pernicious gas away) it *settles* there and destroys animal life.

The Valley of Death, in Java, is covered with the skeletons of birds, beasts, and human beings, which have been suffocated by the carbonic acid gas which abounds in the fatal valley.

Q. *Why do persons in a crowded* CHURCH *feel* DROWSY?

A. 1st—Because a *large portion* of the *oxygen* of the air, which alone can sustain healthy action, has been consumed by the lungs of the congregation · and

2ndly—The air of the church is impregnated with carbonic acid gas, which (being a strong narcotic) produces drowsiness in those who inhale it.

Q. *Why do persons, who are much in the* OPEN AIR, *enjoy the best health?*

A. Because the air they inhale is *much more pure.*

Q. *Why is* COUNTRY AIR *more pure, than the air in* CITIES?

A. 1st—Because there are fewer inhabitants to vitiate the air:

2ndly—There are more trees to restore the pure character of the vitiated air: and

3rdly—The free circulation of air prevents the accumulation of vitiated products.

For the same reason, running streams are pure and wholesome, while stagnant waters are the contrary.

Q. *Why does the* SCANTINESS *of a country population render the* COUNTRY AIR *more pure?*

A. Because the fewer the inhabitants, the *less carbonic acid* will be thrown into the atmosphere; and thus country people inhale *pure air*, instead of air impregnated with carbonic acid gas.

Q. *Why do trees and flowers help to make country air* WHOLESOME?

A. 1st—Because they *absorb* the *carbonic acid* generated by the lungs of animals, putrid substances, and other noxious exhalations: and

2ndly—Trees and flowers restore to the air the *oxygen*, contained in the carbonic acid, which they absorb.

Q. *Why is the air of* CITIES *less wholesome than* COUNTRY *air?*

A. 1st—Because there are more *inhabitants* to vitiate the air:

2ndly—The *sewers*, *drains*, *bins*, and *filth* of a *city*, very greatly vitiate the air:

3rdly—The streets and alleys prevent a free circulation; and

4thly—There are fewer trees to absorb the excess of carbonic acid gas, and restore *oxygen*.

Q. *Why are persons, who live in close rooms and crowded cities, generally* SICKLY?

A. Because the air they breathe is

not pure; but is both *defective in oxygen*, and also impregnated with *carbonic acid*.

Q. *Where does the carbonic acid of close rooms and cities* COME *from?*

A. From the lungs of the inhabitants, the sewers, drains, and other like places, in which organic substances are undergoing *decomposition.*

Q. *What* BECOMES *of the carbonic acid of crowded cities?*

A. Some of it is *absorbed* by *vegetables;* and the rest is *blown away* by the *wind*, and diffused through the whole volume of the air.

Q. *Does not this constant diffusion of carbonic acid affect the* PURITY *of the* WHOLE *air?*

A. No: because it is wafted by the wind from place to place, and *absorbed* in its passage by the *vegetable world.*

Q. *What is* CHOKE DAMP?

A. *Carbonic acid gas* accumulated at the bottom of wells and pits: which renders them noxious, and often fatal to life.

Q. *Why is not this carbonic acid* TAKEN UP *by the air and* DIFFUSED, *as it is in cities?*

A. Because it *cannot rise* from the *well* or *pit*, in consequence of being heavier than air; and no wind can get to it, to help its diffusion.

74½ atoms of carbonic acid weigh as much as 100 lbs. of atmospheric air.

Q. *Why are persons sometimes killed, by leaning over* BEER VATS?

A. Because vats (where beer has been made) contain large quantities of *carbonic acid gas*, produced by the "vinous fermentation" of the beer; and when a man incautiously *leans over a beer vat*, and inhales the carbonic acid, he is immediately *killed* thereby.

Q. *Why are persons often* KILLED, *who enter* BEER VATS *to clean them?*

A. Because carbonic acid (being heavier than *atmospheric air*) often rests upon the *bottom of a vat:* when, therefore, a person enters it, and *stoops to clean the bottom*, he inhales the pernicious gas, which *kills* him.

Q. *Why are persons sometimes killed by having a* CHARCOAL FIRE *in their bed rooms?*

A. Because the *carbon of burning charcoal* unites with the *oxygen of air*;

and forms *carbonic acid gas;* which is a narcotic poison.

Q. *If carbonic acid settles at the* BOTTOM *of a room, how can it injure a person* LYING *upon a* BED, *raised considerably above the floor?*

A. All gases *diffuse* themselves *through each other*, as a drop of *ink* would diffuse itself through a cup of water. If, therefore, a person slept for 6 or 8 hours in a room containing carbonic acid, quite enough of the gas will be diffused throughout the room to produce death.

The *heat* of the fire assists the process of diffusion.

Q. *What are the chief sources of* CARBONIC ACID?

A. 1st—The breath of animals:

2ndly—The decomposition of vegetable and animal matter: and

3rdly—Lime-stone, chalk, and all calcareous stones, in which it exists in a *solid form.*

Q. *From which of these sources is carbonic acid most likely to* ACCUMULATE *to a noxious extent?*

A. From the fermentation and putrefaction of decaying vegetable and animal matters

Q. *How can this accumulation of carbonic acid be* PREVENTED?

A. By throwing *fresh-slaked lime into* places, where such fermentation and putrefaction are going on.

Q. *How will* FRESH-SLAKED LIME *prevent the accumulation of carbonic acid?*

A. By *absorbing* it; and producing a combination called "carbonate of lime."

When lime is slaked, all its carbonic acid is driven off by the heat; therefore, it is free to combine with more.

Q. *Does not heavy rain prevent the accumulation of carbonic acid, as well as quick-lime?*

A. Yes; an abundant supply of *water* will prevent the accumulation of carbonic acid, by *dissolving* it.

N.B. Red heat (as a pan of red-hot coals, or a piece of red-hot iron) will also soon disperse the carbonic acid gas accumulated in a pit or well.

Q. *What effect has carbonic acid on the* WATER, *in which it is dissolved?*

A. It renders it slightly *acid* to the taste.

Q. *Can the* CAPACITY *of water for dissolving carbonic acid be increased?*

A. Yes. Carbonic acid may be *forced* into water by *pressure* to a considerable extent

Q. *How much carbonic acid gas is forced into* AERATED WATERS?

A. About five times their own volume.

Q. *Which of the aërated waters is the most common?*

A. That called soda water, though it very rarely contains any soda.

Q. *Of what then is it made?*

A. Chalk or lime and sulphuric acid added to water.

Q. *What effect does this mixture produce?*

A. The lime and acid combine into "sulphate of lime," and give off carbonic acid as a gas.

Q. *What effect has this gas on the water?*

A. It makes it sparkle, and gives it a pungent acid flavour.

Q. *When the cork is drawn why does the water effervesce?*

A. Because much of the imprisoned gas flies out, and in so doing pushes into bubbles the water which obstructs its passage.

Q. *What causes the mist or fine shower when the cork is suffered to fly out suddenly?*

A. It is partly due to water driven out of the bottle by the escaping gas, and partly to the sudden expansion of the imprisoned air.

Q. *How does the sudden expansion of the imprisoned air contribute to this effect?*

A. When air expands, its temperature declines, and can no longer hold suspended the same quantity of vapour it did before.

Q. *What becomes of it?*

A. It is given off, just as rain is, when the atmosphere is saturated and its temperature falls.

Q. *What produces the carbonic acid gas of* GINGER BEER, BOTTLED PORTER, *and* SPARKLING WINES?

A. The vinous fermentation which goes on after they are bottled and corked down.

Q. *Why is there less froth in* DRAUGHT *than in* BOTTLED ALE?

A. Because some of its carbonic acid gas escapes every time the ale is drawn.

Q. *Why does the effervescence of porter last longer than that of water and wine?*

A. Because porter being more sticky and thick, the bubbles of its froth do not break so soon.

Q. *Why does fresh* SPRING WATER SPARKLE *when poured from one vessel to another?*

A. Because fresh spring and pump water contain *carbonic acid:* and the presence of this gas makes the water *sparkle.*

Much of the froth and bubbling of ale, beer, water, &c., when they are "poured high," is due to common air imprisoned by the action of dropping water.

Q. *What is the* FERMENTATION *of* BEER *and* WINE?

A. The escape of carbonic acid, produced by the change of *sugar* into *alcohol.*

¶ Q. *What is* AL'COHOL?

A. The *spirit* of beer and wine obtained by fermentation.

Q. *Of what* ELEMENTS *is* ALCOHOL *composed?*

A. Of carbon, oxygen, and hydrogen.

Of ALCOHOL, 4 parts are carbon; 2 oxygen; and 6 hydrogen.

Q. *What are the* ELEMENTS *of grape* SUGAR?

A. Carbon, oxygen, and hydrogen, all equal proportions.

Q. *What* CHANGES *does* SUGAR *undergo by* FERMENTATION?

A. It is first decomposed; and then

its elements re-unite in different proportions; producing *al'cohol, carbonic acid*, and *water*.

Of SUGAR, one portion is alcohol; and another carbonic acid: as may be seen by the following table:—

	Carbon	*Oxygen*	*Hydro*
Every atom of anhydrous sugar contains	12	12	12
Two atoms of alcohol contain	8	4	12
Four atoms of carbonic acid contain	4	8	0
	12	12	12

N.B.—"Anhydrous sugar" is sugar *dried* at 300°.

Q. *How does* SUGAR *form* AL'COHOL *by fermentation?*

A. *Two-thirds* of its carbon and *one-third* of its oxygen re-unite with the hydrogen, and generate *al'cohol.*

Q. *How does* SUGAR *form carbonic acid by fermentation?*

A. The remaining *one-third* of its carbon and *two-thirds* of its oxygen re-unite, and generate *carbonic acid*

Q. *What* BECOMES *of the al'cohol which is thus generated by fermentation?*

A. It mixes with the *water*, and forms the *intoxicating* part of beer and wine

Q. *What is the most common reason for beer, wine, and other fermented liquors turning sour?*

A. Air gets to them, and its oxygen acidifies the alcohol, turning it into

Sugar passes at once into vinegar, when it is fermented in the open air.

Q. *Why is* BARLEY MALTED?

A. Because *germination* is produced by the artificial heat; and in germination, the *starch* of the *grain* is converted into *sugar*.

Q. How *is barley malted?*

A. It is *moistened with water*, and *heaped up*; by which means, great heat is produced, which makes the *barley sprout*.

See "spontaneous combustion," *p.* 57.

Q. *Why is not the barley suffered to* GROW *as well as* SPROUT?

A. Because plants in the *germ* contain more sugar than in any other state; as soon as the germ *puts forth shoots*, the *sugar* of the plant is *consumed* to support the shoot.

Q. *How is barley* PREVENTED *from* SHOOTING, *in the process of* MALTING?

A. It is put into a *kiln*, as soon as it sprouts; and the heat of the kiln checks or destroys the young shoot.

Q. *What is* YEAST?

A. The foam of beer (or of some similar liquor) produced by *fermentation.*

Q. *Why is* YEAST *used in* BREWING?

A. Because it consists of a substance called glu'ten, undergoing putrefaction in which state it possesses the peculiar property of exciting *fermentation.*

If the gluten were not in a putrefying state, it could not produce fermentation.

Q. *What is glu'ten?*

A. A tough elastic substance, composed of carbon, oxygen, hydrogen, and nitrogen.

It is the presence of nitrogen which gives yeast the power to excite fermentation.

Q. *Does* MALT *contain glu'ten?*

A. Yes. The infusion of malt, called "sweet-wort," contains an *abundance* of glu'ten; and the yeast (which converts its *sugar* into *alcohol*) converts this *glu'ten* into *yeast.*

Q. *Why is* YEAST *needful, in order to make the infusion of malt into* BEER?

A. Because the presence of a putrefying body containing nitrogen is essential in order to convert sugar into alcohol.

Q. *What* EFFECT *has yeast upon the sweet-wort?*

A. It causes the SUGAR of the wort to be converted into *al'cohol* and *carbonic acid*; and its GLU'TEN into yeast.

Q. *What change is produced in gluten by* PUTREFACTION?

A. Its elements are loosened from their former *conditions of combination*, and re-arranged (with the addition of oxygen from the air) into a *new series.*

Q. *What is the difference between* FERMENTATION *and* PUTREFACTION?

A. FERMENTATION is a change effected in the elements of a body composed of carbon, oxygen, and hydrogen, *without nitrogen.* PUTREFACTION is a change effected in the elements of a body composed of carbon, oxygen, hydrogen, and *nitrogen.*

Q. *What* NEW COMPOUNDS *are produced by the change called fermentation?*

A. *Alcohol* and *carbonic acid.*—The alcohol is still further changed (unless the process be *checked*) into *ace'tic* acid

Q. *What new compounds are produced by the change called* PUTREFACTION?

A. The carbon, oxygen, hydrogen, and nitrogen, of the original substance (being separated by decomposition) re-unite in the following manner. 1. Carbon and oxygen unite to form *carbonic acid.* 2. Oxygen and hydrogen unite to form *water.* 3. Hydrogen and nitrogen unite to form *ammonia.*

Hartshorn is a solution of ammonia in water.

N.B.—When bodies containing sulphur and phosphorous putrefy, the *sulphur* and *phosphorus* unite with *hydrogen*, and form *sulphuretted* and *phosphuretted hydrogen* gases.

Q. *What* BECOME *of these several products of putrefaction?*

A. They are all elastic bodies, and *escape into the air.*

N.B.—*Water* in the condition of *vapour*, is both elastic and gaseous

Q. *What is the cause of the* OFFENSIVE SMELL *which issues from putrefying bodies?*

A. The evolution of *ammonia*, or of *sulphuretted* and *phosphuretted hydrogen* gases; all of which have pungent and offensive odours.

Q. *Why do boiled* EGGS DISCOLOUR A SILVER SPOON?

A. Because they contain a small portion of *sulphur*, which *unites with the silver*, and *tarnishes it* as soon as it is moistened with saliva.

Both the white and yolk contain sulphur—the latter more abundantly. The tarnish is a sulphuret of silver, and may be easily removed by rubbing with hartshorn or table salt.

Q. *What causes the offensive smell of* STALE *hard boiled* EGGS?

A. The *hydrogen* of the egg combining with its *sulphur* and *phosphorus*, form *sulphuretted* and *phosphuretted hydrogen;* both of which gases have an offensive odour.

Of an egg 55 parts are carbon, 16 nitrogen, 7 hydrogen, and the remaining 22 are oxygen, phosphorus, and sulphur

Q. *Why is it* NOT *needful to put* YEAST *into* GRAPE *juice, in order to produce fermentation?*

A. Because grape juice contains a sufficient quantity of a nitrogenized substance like *yeast*, to produce fermentation without it.

Nitrogenized, i.e. containing nitrogen.

Q. *Why do not* GRAPES *ferment, while they hang on the* VINE?

A. Because the *water of the juice* evaporates through the skin, and allows the grapes to shrivel and dry up, after they are ripe.

Fermentation cannot occur unless the sugar be dissolved in a sufficient quantity of *water*.

Q. *What is the* FROTH *or* SCUM *of fermented liquors?*

A. Putrefying glutinous substances (resembling yeast), which rise to the surface from their *lightness*.

Q. *Why is beer* FLAT, *if the cask be left open too long?*

A. Because too much of the *carbonic acid gas*, (produced by fermentation) is suffered to escape.

Q. *Why are beer and porter made stale by being exposed to the* AIR*?*

A. Because too much of the *carbonic acid gas*, (produced by fermentation) is suffered to escape.

Q. *Why does beer turn* FLAT, *if the* VENT PEG *be left out of the tub?*

A. Because the *carbonic acid gas escapes* through the vent hole.

Q. *Why will* NOT *beer run out of a tub, till the* VENT PEG *is taken out?*

A. Because the upward pressure of the external air (admitted through the *tap*) holds the liquor back,—not being counterbalanced by any pressure of air on the *surface* of the liquid

The upward pressure of air may be illustrated by the following simple experiment:—Fill a wine glass with water; cover the top of the glass with a piece of writing paper; turn the glass upside down, and the water will not run out. The paper is used merely to give the air a medium sufficiently dense to act against.

Q. *Why does the beer run* FREELY, *immediately the* VENT PEG *is taken out?*

A. Because air rushes immediately *through the vent hole at the top of the tub*, to counterbalance the air admitted by the tap; in consequence of which the liquid escapes by its own weight.

Q. *Why does liquor flow reluctantly out of a* BOTTLE *held upside down?*

A. Because the *upward pressure of the air*, interferes with its free escape from the narrow mouth of the bottle.

Q. *Why should a bottle be held* OBLIQUELY, *in order to be emptied of its liquor?*

A. Because the liquor will then run out by the *under portion* of the neck, and allow the air to flow in by the *upper part* to counterbalance the upward pressure.

Q. *Why does wine (poured from a bottle* QUICKLY) *spirt about, without going into the decanter?*

A. Because it fills the *top of the decanter* (like a *cork*), and leaves *no room* for the air inside to *escape;* the decanter, therefore, (being *full of air*) refuses to admit the *wine.*

Q. *Why does the* EFFERVESCENCE *of soda water and ginger-beer very soon go off?*

A. Because the *carbonic acid,* (which produced the effervescence) very rapidly *escapes* into the air.

Q. *Why is boiled water* FLAT *and insipid?*

A. Because the whole of the *carbonic acid* is expelled by boiling, and escapes *into the air.*

Q. *Why does* YEAST *make bread* LIGHT?

A. Because it produces a species of fermentation on the starch and glu'ten of flour, as it does in the sugar of malt.

Q. *How does* FERMENTATION *make the dough* RISE?

A. During fermentation, *carbonic acid gas is evolved;* but the sticky texture of the dough will not allow it to *escape;* so it *forces up little bladders* all through the dough.

Q. *Why is* DOUGH *placed before a fire?*

A. 1st—Because the heat of the fire *increases fermentation:* and

2ndly.—It *expands the gas* confined in the little bladders; in consequence of which, the bubbles are *enlarged*, and the dough becomes lighter and more porous.

Q. *Why is bread* HEAVY *if the dough be removed from the fire?*

A. Because the dough *gets cold*, and the air in the bladders *condenses:* In consequence of which, the paste falls,—and the bread becomes close and heavy.

Q. *Why is wheaten bread more* NUTRITIOUS *than that made from any other grain?*

A. Because wheat contains more gluten than other grains, on which its nutritive quality depends.

Good wheat flour contains about 25 per cent. of gluten.

Q. *What causes the heat of fire?*

A. The heated carbon of fuel *combines* with *oxygen* from the *air*, and produces *carbonic acid gas*, by which chemical action *heat* is evolved.

Q. *What causes the heat of animal bodies?*

A. The *carbon* of the *blood* combines with *oxygen* from the *air inhaled*, and produces *carbonic acid gas:* which evolves heat in a way similar to burning fuel.

Q. *Whence does the* HEAT *of a* DUNGHILL *arise?*

A. The straw, &c., of the *dunghill*, undergoes *fermentation* from decay, and produces *carbonic acid gas;* from which heat is evolved by a species of combustion, as in the two former cases.

Q. *How does the formation of* CARBONIC ACID *(in all these cases) produce heat?*

A. Carbonic acid has less power of holding *latent heat*, than *carbon* and *oxygen* have: when, therefore, these elements are changed into carbonic acid, latent heat is given off, and made *sensible*.

Q. *Why do persons throw* LIME *into bins and sewers, to* PREVENT *their offensive smell in summer time?*

A. Because they contain various gases, which readily *combine with lime;* and neutralize their offensive odours.

Q. *Why should* WATER *(used for washing) be exposed to the air?*

A. Because it is made *softer* by exposure to the air.

Most spring water holds lime in solution as a *bicarbonate*, in consequence of the presence of abundant carbonic acid. Carbonic acid escapes by exposure to air—and the lime is, consequently, deposited as a carbonate. The bicarbonate of lime contains twice as much carbonic acid as the carbonate.

Q. *Why is hard* WATER *made* SOFTER *by exposure to air?*

A. 1st—Because the mineral *salts* (which cause its hardness) *subside;* and

2ndly—Because the carbonic acid of the water makes its escape into the air.

Q. *How is the carbonic acid of water produced?*

A. By the presence of what is called the bicarbonate of *lime*, which is frequently held in solution by hard water.

Bicarbonate of lime is a salt, composed of lime and carbonic acid.

Q. *Why is* HARD WATER *more agreeable to* DRINK, *than soft water?*

A. Chiefly because it contains carbonic acid.

Q. *Why is water,* FRESH *from the pump, more* SPARKLING, *than after it has been drawn some time?*

A. Because water fresh from the pump contains carbonic acid, which soon escapes into the air, and leaves the water flat and stale.

Q. *Why is* QUICK-LIME *formed by subjecting chalk and limestone to intense heat in a kiln?*

A. Because the *carbonic acid* (which rendered it *mild*) is driven off by the heat of the kiln: and the lime becomes *quick* or *caustic.*

Chalk and lime-stone are not *burnt*, but *calcined* by the heat of the kiln.

Q. *What is* MORTAR?

A. Lime mixed with sand and water.

Q. *What is the difference between* QUICK-LIME *and* SLACKED-LIME?

A. Slacked-lime is quick-lime to which water has been added.

When quick-lime is slacked, by the addition of water, great heat is given out: the *latent heat* of the fluid water being made sensible when it becomes solid by uniting with the lime.

Q. *Why does* MORTAR *become* HARD, *after a few days?*

A. Because the lime *re-imbibes* from the air the carbonic acid which had been *expelled by fire;* and the loose powder again becomes as hard as the original *lime-stone.*

Q. *Explain in what way* MORTAR *is adhesive.*

A. When the carbonic acid is expelled, the hard lime-stone is converted into a loose *powder*, which (being mixed with sand and water) becomes a soft and sticky *plaster;* but, as soon as it is placed between bricks it *re-imbibes* carbonic acid, and hardens it to *lime-stone* again.

CHAPTER XX.

CARBURETTED HYDROGEN GAS

Q. *What is* CHOKE-DAMP?

A. *Carbonic acid gas* accumulated at the bottom of wells and pits. It is called CHOKE damp, because it *chokes* (or suffocates) *every animal* that attempts to *inhale it.* (*See p.* 266.)

It suffocates without getting into the *lungs*, by closing the outer orifice *spasmodically*.

Q.* *What is marsh-gas or* FIRE-DAMP?

A. *Carburetted hydrogen gas* accumulated on marshes, in stagnant waters, and coal pits; it is frequently called "inflammable air."

Q. *What is* CARBURETTED HYDROGEN GAS?

A. *Carbon* chemically combined with *hydrogen.*

Q. *How may* CARBURETTED HYDROGEN GAS *be* PROCURED *on marshes?*

A. By stirring the mud at the bottom

of any stagnant pool, and collecting the gas (as it escapes upwards) in an inverted glass vessel.

Q. *What is* COAL GAS?

A. *Carburetted hydrogen*, extracted from coals by the heat of *fire*.

Q. *Why is carburetted hydrogen gas called* FIRE-DAMP, *or inflammable air?*

A. Because it very readily *explodes*, when a light is introduced to it.

Provided atmospheric air be present.

Q. *Why is carburetted hydrogen gas frequently called* MARSH GAS?

A. Because it is generated in *meadows and marshes* from putrefying vegetable substances.

See ignis fatuus, 298.

Q. *What gas is evolved by the* WICK *of a burning* CANDLE?

A. *Carburetted hydrogen gas:* The carbon and hydrogen of the tallow *combine* into a gas from the heat of the flame; and this gas is called *carburetted hydrogen.*

Q. *Why does the air in coal-mines frequently* EXPLODE?

A. Because the *carburetted hydrogen*

gas (generated in these mines by the coals) having mixed with common air, explodes, when a light is incautiously introduced.

Q. *How can miners* SEE *in coal-pits, if they may never introduce a* LIGHT ?

A. Sir Humphrey Davy invented a lantern for the use of miners, called "the Safety Lamp;" which may be used without danger.

Q. *Who was Sir Humphrey Davy?*

A. A very celebrated chemist, born in Cornwall, 1778: he died in 1829.

Q. *What sort of thing is the* SAFETY LAMP ?

A: A kind of lantern, *covered with a fine wire gauze*, instead of glass or horn.

Q. *How does this fine* WIRE GAUZE *prevent* EXPLOSION *in a coal mine?*

A. By killing the flames inside the lamp, and thus preventing their transmission to the inflammable gas of the mine.

N.B.—The interstices of the wire gauze must not be fewer than 400 to a square inch.

Q. *Why will not* FLAME PASS THROUGH *very fine wire* GAUZE ?

A. Because the wire-gauze is a very

rapid conductor of heat; and when the flaming gas burning in the lamp reaches it, so much heat is drawn off that the flame is extinguished; and, consequently, it cannot ignite the explosive gas of the mine.

Sir Humphrey Davy says: "When two vessels filled with a gaseous explosive mixture are connected with a narrow tube, if the contents of one vessel are fired, the flame will not communicate to the other vessel; for the flame being extinguished by cooling, its transmission is rendered impossible."

Q. *Does the gas of a* COAL-PIT *get* THROUGH *the wire-gauze* INTO *the* LANTERN?

A. Yes: and the inflammable gas ignites, and burns *inside the lamp:* but no danger arises, so long as the wire-gauze does not become very much heated.

Q. *How can the miner tell when the moment of* DANGER *has arrived?*

A. By observing when the wire-gauze becomes *red-hot;* danger is then present: for should the heat rise *higher* the *flame* would *pass* and produce an explosion, because the *wire* would be no longer able to cool it.

N.B.—When the carburetted hydrogen gas *explodes* from a miner's candle, the miner sometimes perishes in the *blast of the flame;* and sometimes suffers *suffocation* from the carbonic acid thus produced.

CHAPTER XXI.

PHOSPHURETTED HYDROGEN GAS.

Q. *From what do the very* OFFENSIVE EFFLUVIA *of* DEAD BODIES *in church-yards arise?*

A. From a gas called PHOSPHURETTED HYDROGEN: which is *phosphorus* combined with *hydrogen gas.*

The escape of ammonia and sulphuretted hydrogen contributes much to this offensive odour.

Q. *What is* PHOSPHORUS?

A. A pale amber-coloured substance, resembling wax in appearance. The word is derived from two Greek words, which mean "*to produce or bring light.*" (φῶς-φέρειν.)

Q. *How is* PHOSPHORUS *obtained?*

A. By heating bones to a white heat: by which means, the animal matter and charcoal are *consumed*, and a substance called "*phosphate of lime,*" is left behind.

Q. *What is the* PHOSPHATE OF LIME?

A. The principal constituent of bones.

It is a compound of phosphorus, oxygen, and lime.

Phosphorus and oxygen in combination constitute phosphoric acid.

Q. *Of what is the ignitable part of* LUCIFER MATCHES *made?*

A. Of phosphorus; and above 250 thousand lbs. are used every year in London alone, merely for the manufacture of lucifer matches.

Q. *Why do lucifer matches so readily ignite?*

A. Because phosphorus (with which they are tipped) inflames with such a slight degree of heat, that even gentle pressure or friction will raise its temperature enough to kindle it into flame.

Q. *What is the cause of the* IGNIS FATUUS, *Jack o'Lantern, or Will o'the Wisp?*

A. This luminous appearance (which haunts meadows, bogs, and marshes) arises from the *gas of putrefying animal and vegetable substances*; especially from decaying fish.

The Welsh "Corpse Candles" are the same things.

Q. *Why are these luminous phantoms so seldom seen?*

A. Because phosphoric hydrogen is so very volatile, that it generally escapes into the air in a thinly diffused state.

If phosphorus be boiled with milk of lime, and the beak of the retort placed under water, bubbles of phosphuretted hydrogen will rise successively through the water, and (on reaching the surface) burst into flame. It is the singular property of this gas to ignite spontaneously in air when it has been produced by the action of lime or potassa on water; when the gas is procured directly from hydrated phosphorus, it does not ignite spontaneously, because it is more pure.

Q. *Why does an ignis fatuus, or Will o'the Wisp,* FLY *from us when we* RUN *to* MEET *it?*

A. Because we produce a current of air in front of ourselves, (when we run *towards* the ignis fatuus) which drives the light gas *forwards.*

Q. *Why does an ignis fatuus run* AFTER *us, when we* FLEE *from it in a fright?*

A. Because we produce a current of air in the way we run, which *attracts* the light gas in the same course; drawing it after us, as we run away from it.

Q. *Is not a kind of Jack o'Lantern sometimes produced by insects?*

A. Yes; swarms of luminous insects passing over a meadow, sometimes produce an appearance similar to the ignis fatuus.

Q. *May not many* GHOST *stories have arisen from some ignis fatuus lurking about churchyards?*

A. Perhaps all the ghost stories (worthy of any credit at all) have arisen from the ignited gas of churchyards—lurking about the tombs: to which *fear* has added its own creations.

CHAPTER XXII.

WIND.

Q. *What is wind?*

A. Wind is *air* in *motion.*

Q. *What* PUTS *the air in motion, so as to produce* WIND?

A. The principal causes are variations of *heat and cold;* produced by the succession of day and night, and of summer and winter.

Q. *What effect has* HEAT *upon the air?*

A. Heat *rarefies* the air, and causes it to expand.

Q. *How do you* KNOW *that heat causes the air to* EXPAND?

A. If a bladder *half full of air* (tied tight round the neck) be laid before a *fire*, the air will expand by the heat, and *fill* the bladder.

Q. *What effect is produced upon air by* RAREFACTION?

A. It is made *lighter*, and *ascends through colder strata;* as a cork (put at the bottom of a basin of water) rises to *the surface.*

Q. *Prove that rarefied air* ASCENDS.

A. When a boy sets fire to the cotton or sponge of his balloon, the flame *heats the air;* which becomes so *light*, that it ascends, and *carries* the balloon with it.

Q. *What effect is produced upon* AIR *by* COLD?

A. It is *condensed*, or squeezed into a smaller compass; in consequence of which, *it becomes heavier*, and descends towards the ground.

Q. *Prove that air is condensed by* COLD.

A. Lay a bladder half full of air before a fire, till it has become fully *inflated;* if it be now removed *from* the fire, the bladder will *collapse* again, because the air condenses into its former bulk.

Q. *What is meant by the bladder* "COLLAPSING?"

A. The skin becoming *wrinkled*, *shrivelled*, and *flabby;* because there is not sufficient air inside to *fill* it.

Q. *How do you* KNOW *that* CONDENSED *air will* DESCEND?

A. Because a fire balloon *falls* to the earth, so soon as the spirit in the cotton is *burnt out*, and the air of the balloon has become *cold again.*

Q. *Does the sun heat the* AIR, *as it does the* EARTH?

A. No: the air is *not heated* by the *rays of the sun;* because air (like water) is a very *bad conductor.*

Q. *How is* AIR HEATED?

A. By *convection*, thus:—The *sun* heats the *earth*, and the earth *heats the air resting upon it;* this hot air *rises*, and is succeeded by *colder air*, which is heated in a similar way; till the whole volume is *warmed* by these "convective currents."

Q. *What is meant by* "CONVECTIVE CURRENTS" *of hot air?*

A. Streams of air, heated by the

earth, which *rise upwards* and *carry heat with them.* (*See p.* 252.)

Q. *Is the air in a* ROOM *in perpetual motion, as the air* ABROAD *is?*

A. Yes; there are always *two currents of air* in any room we occupy: one of *hot* air flowing *out* of the room, and another of *cold* air flowing *into* the room.

Q. *How do you* KNOW, *that there are these* TWO *currents of air in every occupied room?*

A. If I hold a lighted candle near the *top* of the *door*, the flame will be blown *outwards* (towards the *hall*); but if I hold the candle at the *bottom* of the *door*,* the flame will be blown *inwards* (into the *room.*)

N.B.—This is not the case when a *fire* is in the room. When a fire is lighted, an inward current is drawn through *all* the crevices.

Q. *Why would the flame be blown* OUTWARDS (*towards the* HALL), *if a candle be held at the* TOP *of the door?*

A. Because the air of the room, being heated, &c., *ascends;* and (floating about the upper part of the room) escapes *through the crevice* at the *top* of the *door*, producing a current of air from the room into the *hall*

Q. *Why would the flame be blown* INWARDS *(into the* ROOM*), if a candle be held at the* BOTTOM *of the door?*

A. Because the *cold air* from without is rushing *inwards*, through the crevice at the bottom of the door, to *drive* the *light warm* air out at the top.

Q. *How does warm air make its* ESCAPE *from a room?*

A. The *warm* air is *pressed* out by the *cold* air coming in below; and escapes by means of the crevices at the top of the room.

Q. *Why are not all places, which lie under the same parallel of latitude, of the same temperature?*

A. Because various disturbing circumstances tend to vary the mean temperature.

Q. *What disturbing circumstances affect the temperature of particular situations?*

A. 1st—The elevation and form of the land:

2ndly—The proximity of the sea:

3rdly—Mountains, swamps, and forests:

4thly—The nature of the soil: and

5thly—The prevalence of cold or warm winds.

Q. *What effect is produced on temperature by the configuration of* LANDS?

A. Islands and peninsulas are warmer than continents; bays and inland seas also tend to raise the mean temperature.

Q. *What effect has the* SEA *on temperature?*

A. In *warm* climates it tends to *diminish* the heat; in *cold* climates to *mitigate* the cold.

Q. *What effect have* MOUNTAINS *on temperature?*

A. Chains of mountains which ward off *cold* winds, raise temperature; but mountains which ward off *south* and *west* winds, lower it.

Q. *What effect has* SOIL *on temperature?*

A. A sandy soil which is dry, is warmer than a marshy soil which is wet, and subject to great evaporation.

For effects of forests on temperature, see p. 167.

Q. *Does all wind maintain the* SAME *velocity?*

A. The *velocity* of wind varies from 100 miles an hour in the *tornado*, to the scarcely perceptible motion of a *gentle breeze*.

Q. *How does the rotation of the earth upon its axis affect the motion of the air?*

A. In two ways. 1st—As the earth moves round its axis, the air is left somewhat *behind;* and, therefore, seems to a body carried with the surface of the revolving earth, to be going in the opposite direction: and

2ndly—As the earth revolves, different portions of its surface are continually passing under the vertical rays of the sun.

Q. *When are the rays of the sun called* "VERTICAL RAYS?"

A. When the sun is in a *direct line* above any place, his rays are said to be "vertical" to that place.

Q. *Illustrate the manner in which the earth's surface passes under the vertical sun.*

A. Suppose some part of the brass meridian of a globe to represent the vertical sun; as you turn the globe round, *different parts* of its surface will pass under that part of the brass rim in constant *succession.*

Q. *Why is it* NOON-DAY *to the place over which the* SUN *is* VERTICAL?

A. Because the sun is *half-way* between rising and setting to that place.

Q. *Show how this rotation of the earth affects the* AIR.

A. If we suppose some part of the brass meridian to be the vertical sun, the whole column of air *beneath* will be heated by the *noon-day rays;* that part which the sun has *left*, will become gradually *colder and colder;* and that part to which the sun is *approaching*, will grow constantly *warmer and warmer.*

Q. *Then there are* THREE *conditions of air about this spot?*

A. Yes: the air over the place, which has *passed* the meridian, is *cooling;* the air under the *vertical sun*, is the *hottest;* and the air, which is over the place *about to pass* under the meridian, is *increasing in heat.*

See fig. on p. 309. The column A (which the sun has passed) is cooling: B is under the vertical sun; and C is *increasing in heat*

Q. *How does this* VARIETY *in the* HEAT *of* AIR *produce* WIND?

A. The air always seeks to *preserve a condition of equilibrium;* so, *cold air* rushes into the place occupied by neighbouring warm air, and causes it to form an upward current.

Q. *Why does not the wind* ALWAYS BLOW ONE *way, following the direction of the* SUN?

A. Because the direction of the wind is subject to perpetual interruptions from *hills* and *valleys*, *deserts* and *seas*, &c.

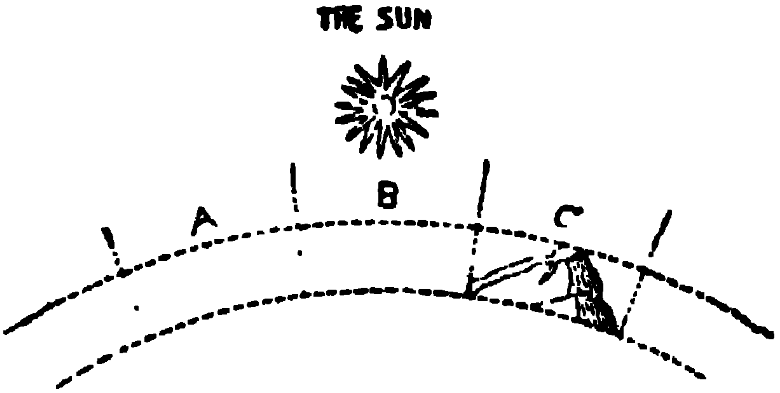
Q. *How can* HILLS *and* MOUNTAINS ALTER *the course of the* WINDS?

A. Suppose a wind (blowing from the north) comes to a mountain; as it cannot pass *through it*, it must either rush *back* again, or *fly off at one side*, (as a *marble*, when it strikes against a *wall*.)

Q. *Do* MOUNTAINS *affect the wind in any* OTHER *way?*

A. Yes; many mountains are *capped with snow*, and the *warm air* is *condensed*, when it comes in contact with them: as soon as the *temperature of the air* is changed, the *direction* of its currents are altered also.

See figure on next page.



Suppose A B C to be *three columns of air*. A, the column of air which is *cooling down*: B, the column to which the *sun is vertical*; and C, the column which *is to be heated next*. In this case, the cold air of A will rush towards B; because the air of B is *hotter* than that of A. But suppose now C to be a *snow-capped mountain*; as it comes under B, it preserves the air round it at its low temperature still, and therefore checks for a time the ascent of the air in that direction.

Q. *How can the* OCEAN *affect the direction of the* WIND?

A. When the ocean rolls beneath the *vertical sun*, it is *not made so hot* as the *land* is; in consequence of which, the general direction of the wind is from tracts of *ocean* towards tracts of *land.*

Q. *Why is not the* WATER *of the sea made so* HOT *by the vertical sun, as the surface of the* LAND?

A. 1st—Because the *evaporation* of the sea is greater than that of land: and

2ndly—The constant *motion* of water prevents the increase of temperature at the surface.

Q. *Why does the* EVAPORATION *of the sea prevent its surface from being heated by the vertical sun?*

A. Because its heat is *absorbed* in the generation of *vapour*, and carried off into the air.

Q. *Why does the* MOTION *of the sea prevent its surface from being heated by the vertical sun?*

A. Because each portion *rolls away*, as soon as it becomes heated, and is succeeded by *another;* and this constant motion prevents the *surface* of the sea from being *more* heated than the water *below* the surface.

Q. *How do* CLOUDS *affect the* WIND?

A. As passing clouds screen the direct heat of the sun from the earth, they diminish the *rarefaction* of the air also: and this is another cause why neither the strength nor direction of the wind is *uniform*.

Q. *Do winds* EVER *blow* REGULARLY?

A. Yes; in those parts of the world, which present a large surface of water, as in the Atlantic and Pacific Oceans.

Q. *What are the regular winds, which blow over the* ATLANTIC *and* PACIFIC *Oceans, called?*

A. They are called "trade winds."

They are called "trade" or "tread winds," because they uniformly pursue one tread or track.

Q. *What service are these winds to merchants?*

A. They are very convenient to merchants, who have to cross the ocean, inasmuch as they always blow uniformly in one direction.

Q. *In what* DIRECTION *do the trade winds blow?*

A. That in the *northern* hemisphere blows from the *north-east:* that in the *southern* hemisphere, from the *south-east.*

Q. *Why do not these polar or trade winds blow from the* FULL NORTH *and* SOUTH, *directly towards the torrid zone?*

A. Because the poles, from which they flow, *move with less velocity* than the surface of the earth over which they pass in their progress towards the equator.

Q. *How does this difference of velocity affect the direction of the wind?*

A. In the same way as hedges, houses, or trees, (to a person in a carriage) seem to be running in an opposite direction.

As the circumference of the earth at the equator is *much larger* than the circumference of the earth at the poles; therefore, every part of the earth's *equatorial* surface must move *much faster*, than the corresponding one at the poles.

Q. *Why do currents of air flow from the* POLES *to the* EQUATOR?

A. Because the air about the equator (being rarefied by the heat of the sun) *constantly ascends*, and thus gives way to the cold air from the poles.

Q. *Is there an* UPPER *as well as a* LOWER CURRENT *in the atmosphere?*

A. Yes; the *upper* current of rarefied air is *from the equator to the poles;* being there condensed, it returns again to the *equator*, forming the *lower* current.

Q. *What effects are produced by the double current of air?*

A. 1st—The warming and cooling of the strata of air:

2ndly—The deposition of rain: and

3rdly—The formation and appearance of clouds.

Q. *How is the* AIR *affected by these opposing currents?*

A. As cold air returns from the poles to the equator, and hot air travels from the equator to the poles, both currents are affected as they come into contact with each other.

Q. *How would these two opposite currents of air cause deposition of* RAIN?

A. The hot current from the equator being mixed with the cold current from the poles, are condensed, and compelled to part with some of their moisture in rain.

Q. *How are* CLOUDS *affected by the equatorial and polar currents of air?*

A. As the currents displace each other by any disturbing cause, *vapour* is *added to or taken from* the clouds, and produce a total change in the "face of the sky."

Q. *Why do the clouds vary almost incessantly even in the calmest day?*

A. In a great measure from some slight disturbance in the separate course of the equatorial and polar currents, whereby the upper current descends, and the lower one rises into the other.

Q. *Do trade-winds blow from the north-east and south-east* ALL *the* YEAR ROUND?

A. Yes, *in the open sea*; that is, in the Atlantic and Pacific Oceans, for about 30 degrees each side of the equator.

Q. *What becomes of the north-easterly and south-easterly trade winds, when they approach the equator?*

A. They are lost in a region of *calms*, in which vessels are often detained for a considerable time.

Q. *Is this region of calms* FIXED *in its position?*

A. No; it shifts its place, according to the sun's distance, and position in regard to the *equator*: being sometimes entirely to the *north* of the equator, and occasionally reaching as far as 2 degrees *south* of it.

Q. *Do the* TRADE WINDS *blow uniformly from north-east and south-east in the* INDIAN OCEAN?

A. No; nor yet in those parts of the *Atlantic* and *Pacific* which verge on the continents.

Q. *How do the* WINDS *blow in the* INDIAN OCEAN?

A. From April to October a *south-west* wind prevails; but from October to April, a *north-east*

Q. *What are these periodical currents of air (which affect the neighbourhood of the Arabian, Indian, and Chinese Seas) called?*

A. They are called MONSOONS.

The word monsoon is of Arabic derivation; *mausim*, (a set time or season.)

Q. *How far do the limits of the* MONSOONS *extend?*

A. From the African shore to the longitude of New Guinea; and *northward* as far as the parallel of latitude, which crosses the Loochoo Isles.

The Loochoo Isles are about 24° north latitude, and 80° east longitude.

Q. *Why do not the winds in the* INDIAN OCEAN *blow south-west from April to October, like the trade winds?*

A. Because the air of Arabia, Persia, India, and China *is so rarefied* by the enormous heat of their summer sun, that the colder air from the south rushes *towards these countries* across the *equator*, producing a SOUTH-WEST wind.

Q. *To what distance does this* SOUTH-WEST *wind prevail?*

A. From 3 degrees south of the equator, to the shores of the Arabian, Indian, and Chinese Seas.

Q. *Why does the wind (in the* INDIAN OCEAN) *blow north-east from October to April?*

A. Because the *southern part of the torrid zone* is most heated when the sun is south of the equator: and the colder air from the north rushes towards the southern tropic, producing a NORTH-EAST wind for six months of the year.

Q. *Are the monsoons as* POWERFUL *as the trade winds?*

A. They are far *more* so, and very often amount to violent gales.

Q. *Why are* MONSOONS *more* USEFUL *to the mariners than the fixed* TRADE WINDS?

A. Because mariners are able to avail themselves of these periodic changes, to go in *one* direction during *one* half of the year, and to *return* in the *opposite* direction during the *other* half.

Q. *How is the change of the monsoons marked?*

A. By an interval of alternating calms and storms.

Q. *Have the winds in* EUROPE *any general directions throughout the year?*

A. We generally find that *easterly* winds prevail during the *spring* of the year; and *westerly* winds in the *summer* and *autumn*.

3-West winds are more frequent in July and August. N-East winds in January, March, April, May, and June; but *least* frequent in July, September, and December.

Q. *When are the* WINDS *in* EUROPE *generally the* HIGHEST?

A. The winds in December and January are generally the highest. Those in March and November the next; and those in August and September are the *least* boisterous.

Q. *Why are the winds of Europe generally* HIGHEST *in* DECEMBER *and* JANUARY?

A. Because the sun is *furthest south* in those months; and (as the heat in these northern regions rapidly *decreases*) the contrast between our temperature and that of the *torrid zone* is greater, in December and January, than in any other two months throughout the year.

Q. *Why does this* CONTRAST *of heat increase the* VIOLENCE *of the* WIND?

A. Because the air always seeks to *preserve* a state of *equilibrium*; therefore, the greater the contrast, the more violent will be the rush of air to *equalize* the two volumes.

Q. *Why are the winds in Europe generally most* PLACID, *during the months of* SEPTEMBER *and* AUGUST?

A. Because August and September are our *warmest months*, when we approach nearest to the heat of the torrid zone; therefore, the air (to and from the equator), moves with *less velocity* in our northern hemisphere in those two months than in any other.

Q. *Shew the goodness and wisdom of* GOD *in this constant tendency of air to equilibrium.*

A. If the torrid zone were not tempered by cold air from the polar regions it would become so hot, that no human being could endure it. If (on the other hand) the polar regions were never warmed by hot air from the torrid zone, they would soon become *insufferably cold.*

Q. *In what* OTHER *way does the mingling of the polar and equatorial atmosphere act* BENEFICIALLY?

A. In the *equatorial* regions, the

great abundance of vegetable life is productive of a very large amount of *oxygen:* In the colder regions, artificial *fires* and dense masses of *animal life,* produce large quantities of *carbonic acid:* The mingling of the polar and equatorial atmosphere assists in supplying each of these regions with the very gas, in which it would be otherwise defective.

Q. *How does the mingling of the* POLAR *and* EQUATORIAL *atmosphere serve to supply each region with the* GAS *it most requires?*

A. The *plants* of the EQUATORIAL regions require *carbonic acid:*—The *animals* of the COLDER regions require *oxygen:*—The currents of air from the *poles* carry *carbonic acid* to the equatorial *plants;* and the currents of air from the *equator* carry *oxygen* to the *animals* which abound nearer the *poles.*

Q. *Why are* EAST WINDS *in England generally* COLD?

A. Because they pass over the cold swampy plains of the North of Europe; and have no great breadth of ocean to flow over afterwards to warm them before they reach our shores.

Q. *Why are* EAST WINDS *in England generally dry?*

A. Because they come over *vast continents* and very little ocean; in consequence of which, they have absorbed *very little water.*

Q. *How does this account for the drying power of the* EAST *winds?*

A. Being dry when they reach our island, they readily imbibe moisture from the air and clouds; and, therefore, *bring dry weather.*

Q. *Why are* NORTH WINDS *in England generally* COLD?

A. Because they come from the *polar regions*, over mountains of snow, and seas of ice.

Q. *Why are* NORTH WINDS *in England generally keen and drying?*

A. Because they come from regions *colder than our own;* and, being *warmed* by the heat of our island, absorb moisture wherever they find it.

Q. *Why are* SOUTH WINDS *generally* WARM *in England?*

A Because they come over the

hot sandy deserts of Africa, which make them hot.

Q. *Why do* SOUTH WINDS *often bring us* RAIN?

A. Because they are much *heated* by the hot sands of Africa; and *imbibe water very plentifully*, as they pass over the Mediterranean Sea and British Channel

Q. *How does this account for the* RAINY *character of* SOUTH *winds?*

A. As soon as they reach our cold climate they are *condensed*, and can no longer hold all their vapour in suspension; in consequence of which, some of it is deposited as rain.

Q. *Why are* WEST WINDS *in England generally* RAINY?

A. Because they come over the *Atlantic Ocean*, and are laden with *vapour*; if, therefore, they meet with the least *chill*, some of the vapour is deposited as rain.

Q. *Why is a fine* CLEAR DAY *sometimes* OVERCAST *in a few minutes?*

A. Because some *sudden change of temperature* has condensed the vapour of the air *into clouds*

Q. *Why are* CLOUDS *sometimes* DISSIPATED *very suddenly?*

A. Because some *dry wind* (blowing over the clouds) *imbibes their moisture*, and carries it off in visible vapour.

Q. *Why do* SOUTH-WEST *winds bring us* RAIN?

A. Because they come from the *torrid zone*, and get *laden with vapour*, in their transit across the *ocean*. But, when they reach our northern island, (being condensed by cold) some of the vapour is precipitated in rain.

Q. *Why do* NORTH-EAST *winds* RARELY *bring* RAIN?

A. Because they come from a climate *colder than our own*, and their capacity for imbibing vapour is *increased*, when they reach our island; in consequence of which, north-east winds *dry the air*, dispel the clouds, and promote evaporation.

Q. *Why does* WIND *sometimes bring* RAIN *and sometimes* FINE *weather?*

A. If the wind be *colder than the clouds*, it will condense their vapour into *rain*: But if the wind be *warmer than the* *clouds*, it will *dissolve* them, and cause them to disappear.

Q. *Why are* MARCH *winds* DRY?

A. Because they generally blow from the east or north-east; and, therefore, sweep over the continent of Europe, and cross the cold waters of the German Ocean.

Q. *What is the* USE *of* MARCH *winds?*

A. They *dry* the soil, which is saturated with the floods of February,—break up the heavy clods,—and fit the land for the *seed* committed to it.

Q. *Why is it said, that* "MARCH COMES IN *like a* LION?"

A. Because it comes in with *blustering east winds*, so essential to dry the soil, lest it *rot the seeds* committed to it.

Q. *Why does* "MARCH GO OUT *like a* LAMB?"

A. Because the water (evaporated by the high winds) falls again in *showers* to fertilize the earth; and these constant showers break the violence of the *winds*.

Q. *Why is it said, that* "*A bushel of* MARCH DUST *is worth a king's ransom?*"

A. Because it indicates that there has

been a continuance of *dry weather:* and unless *March be dry*, the seed will rot in the wet soil.

Q. *Why is it said,* "A DRY *cold* MARCH *never* BEGS BREAD?"

A. Because the *dry cold winds* of March prepare the soil for *seed;* which germinate, and produce fruit in the autumn.

Q. *It is said, that* "A WET MARCH *makes a* SAD *autumn.*" *Explain the reason of this.*

A. If *March* is *wet*, so much seed *rots* in the ground, that the autumn crops are spoiled.

Q. *It is said, that* "MARCH FLOWERS *make* NO *summer* BOWERS." *Explain the reason of this.*

A. If the *spring be very mild*, vegetation gets too forward, and is *pinched by* succeeding *night frosts*, so that the summer produces neither fruits nor flowers.

Q. *It is said,* "A LATE SPRING *makes a* FRUITFUL YEAR." *Explain the reason of this.*

A. If the vegetation of spring be *backward*, frosty nights will *do no harm;* because the fruits and flowers will not put forth their tender shoots, till the nights have become *too warm to injure them.*

Q. *Why is it said, that "*APRIL SHOWERS *bring* MAY FLOWERS*?"*

A. Because April showers supply the principal nourishment on which seeds depend for their development.

Before seeds can germinate, *three* things are essential:—Darkness, Heat, and Moisture.

Q. *Does* RAIN-*water possess any fertilizing properties,* BESIDES *that of mere* MOISTURE*?*

A. Yes; rain-water contains an abundance of *carbonic acid*, and a small quantity of *ammo'nia;* to which much of its fertilizing power is attributed.

Ammonia is a compound of nitrogen and hydrogen. Common hartshorn is only ammonia and water.

Q. *Why has God made* NOVEMBER *a very* RAINY *month?*

A. Because rain hastens the *putrefaction* of the *fallen leaves:* and this makes the earth fertile.

Q. *Why is there* MORE *rain* FROM SEPTEMBER *to* MARCH, *than from March to September?*

A. Because the temperature of the air is *constantly decreasing;* on which account, its *capacity for holding vapour* is on the *decrease* also; and its vapour precipitated as rain.

Q. *Why is there* LESS *rain from March to September, than from September to March?*

A. Because the temperature of the air is *constantly increasing;* on which account, its *capacity for holding vapour* is on the *increase*, and very little is precipitated as rain.

Q. *Why is the rising sun in summer accompanied with a* BREEZE?

A. Because the heat of the rising sun *stops the radiation of heat* from the earth, and *warms its surface.*

Q. *How does this warmth produce a* BREEZE?

A. The air (resting on the earth's surface) being *warmed by contact*, ascends; and *colder air rushing in* to restore the balance, produces the *morning breeze.*

Q. *Why is there often an* EVENING BREEZE *during the summer months?*

A. Because the earth *radiates heat* at *sun-set*, and the air is rapidly cooled down by contact: this condensation causes a *motion in the air*, called the *evening* breeze.

Q. *Why are* TROPICAL ISLANDS *subject to a sea-breeze every morning (i.e. a breeze blowing from the sea to the land)?*

A. Because solar rays are unable to heat the surface of the *sea*, as they do that of the *earth;* therefore, the *air* resting on the *sea* is less heated, than the *air* resting on the *earth;* and the colder sea air blows *inland* to restore equilibrium.

Q. *Why is a land breeze generally less healthy than a sea breeze?*

A. Because it is frequently laden with exhalations from *putrefying animal* and *vegetable* substances.

Q. *Why is a sea breeze fresh and* HEALTHY?

A. Because it passes over the fresh sea, and is *not* laden with noxious exhalations.

It is particularly *healthy*, therefore, to walk on the sea-beach before ten o'clock in the morning; *but less so after sun-set.*

Q. *Why is there generally a fresh breeze from the* SEA *(in English watering places,) during the summer and autumn* MORNINGS?

A. Because *land* is *more heated by the sun*, than the *sea* is; in consequence of which, the cooler sea air glides *inland*, restoring equilibrium by pressing up the light hotter air.

Q. *Why does a sea breeze feel* COOL?

A. Because the sun cannot make the surface of the *sea* so hot as the *land;* therefore, the air which blows from the sea is *cooler* than the air of the *land.*

Q. *Why are tropical islands subject to a land breeze every* EVENING (*i.e. a breeze blowing from the land towards the sea*)?

A. Because the *surface of the land* cools down *faster* (after sun-set), than the surface of the *sea:* in consequence of which, the air of the cold lands is *condensed*, and flows into the warmer regions of the sea—causing a LAND BREEZE.

Q. *Why is the land breeze* COOL?

A. Because the surface of the land is cooled at sun-set *more quickly* than the surface of the sea; therefore, the air from the land feels cool.

Q. *Why is the temperature of islands more* EQUABLE *than that of continents?*

A. Because the *water* around the island mitigates the extreme heat of summer, and *gives out* heat to diminish the extreme cold of winter.

Q. ISLANDS *are* WARMER *in winter than continents. Explain the reason of this.*

A. Unless the *sea be frozen* (which is rarely the case) it is warmer than the frozen land: and the warmth of the *sea* air helps to mitigate the intense cold of the *land* air.

Q. *Explain the cause of sea* WAVES.

A. The wind, pressing *unequally* on the surface of the sea, *depresses* one part more than another; every *depression* causes a corresponding *elevation*, and these undulations are called waves.

It must be remembered that waves have no other than a *vertical motion*, i.e. up and down. Any substance, as a buoy, floating on a wave, is merely elevated and depressed alternately; it does not otherwise change its place.

Q. *If waves are stationary, and only move up and down, why do they seem to advance towards the shore?*

A. This is an ocular deception. When a *corkscrew* is turned round, the thread appears to move forward; and the apparent *onward* motion of the waves of the sea is a similar delusion.

A wave is a *form*, and not a thing; the *form* advances, but not the *substance* of the waves.

Q. *What is the cause of* "BREAKERS?"

A. The interference of rocks or rising banks in the sea with the regular form of the wave, by which the "phase" of the curve is broken.

"The *phase* of the curve" is the outline or arc of the wave.

Q. *What causes the* SPRAY *of waves?*

A. The wind driving the surface of the water from the top of the wave, and scattering the small particles in all directions.

Q. *What is a* TIDE?

A. A wave of the *whole ocean,* which is elevated to a certain height, and then sinks after the manner of a common wave. The interval between the two positions forms a tide.

There are two tides in a lunar day, i. e. 24 hours, 49 minutes.

Q. *What is the* CAUSE *of tides?*

A. The principal cause is the *attraction of the moon;* which raises the waters of the ocean, as they come under her influence by the motion of the earth on its axis.

Q. *Why do we generally feel* COLDER *out-of-doors than in-doors?*

A. Because the air is *always changing;* and before one portion has become heated by our body, another colder portion takes its place. and absorbs more heat.

Q. *Why is a* ROOM *(even without a fire) generally* WARMER *than the* OPEN AIR?

A. Because the air in a room is *not subject to much change*, and soon becomes of the same temperature as our skin, after which it no longer feels cold.

Q. *How fast does wind travel?*

A. A gentle breeze goes at about the rate of 5 miles an hour. A high wind from 20 to 60. A hurricane from 80 to 100 miles an hour.

Q. *How is the* VELOCITY *of winds ascertained?*

A. By observing the velocity of the clouds; and by an instrument contrived for the purpose, called an Anemometer.

Pronounce An-e-mom′-e-ter. From two Greek words *ανεμος* **(wind) and** *μετρον* **(a measure). This term is applied more frequently to an instrument which measures the** *force* **of wind.**

Q. *How is the* VELOCITY *of the clouds ascertained?*

A. By observing the speed of their shadow along the ground: which is found (in a high wind) to vary from 20 to 60 miles an hour.

Q. *Why is there always a strong* DRAUGHT *through the* KEY-HOLE *of a door?*

A. Because the air in the room we occupy is *warmer* than the air in the hall; therefore, the air from the hall *rushes through the key-hole* into the room, and causes a draught.

Q. *Why is there always a strong* DRAUGHT UNDER *the door, and through the crevice on each side?*

A. Because cold air rushes from the hall, to drive the warmer air up the chimney.

Q. *Why is there always a* DRAUGHT *through the* WINDOW *crevices?*

A. Because the external air (being colder than the air of the room we occupy) rushes through the window crevices to drive the warm air up the chimney.

Q. *If you open the* LOWER *sash of a window, there is more* DRAUGHT *than if you open the* UPPER *sash. Explain the reason of this.*

A. If the lower sash be open, *cold external air* will rush freely into the room, and cause a great draught *inwards;* but if the *upper* sash be open, the *heated air* of the room will rush out; and (of course, there will be less draught inwards.

Cold air always flows to the spot occupied by warm air, and displaces it, because it is heavier. Both are drawn down to the earth, by its attraction, but the heavier cold air with the more force; it therefore occupies the lower position, and pushes the warm air upwards.

Q. *By which means is a* ROOM *better* VENTILATED—*By opening the upper or lower sash?*

A. A room is better *ventilated* by opening the *upper sash;* because the hot vitiated air (which always ascends towards the ceiling) *can escape more easily.*

Q. *By which means is a* HOT ROOM *more quickly* COOLED—*By opening the upper or the lower sash?*

A. A hot room is *cooled more quickly* by opening the *lower sash;* because cold air can enter more freely at the *lower* part of the room than at the *upper.*

Q. *Why does wind* DRY *damp* LINEN?

A. Because dry wind (like a dry sponge) imbibes the particles of vapour from the surface of linen, as fast as they are formed.

Q. *Why is the* GALLERY *of all public places* HOTTER *than the* LOWER *parts of the building?*

A. Because the *heated* air *ascends;* and all the *cold air* (which can enter through the doors and windows), till it has become heated, *remains on the floor* of the room.

CHAPTER XXIII.

BAROMETER.

Q. *What is a* BAROMETER?

A. A weather-glass, or instrument to measure the variations in the *weight* of the air.

BAROMETER is a compound of two Greek words, Βαρος (weight) and μετρον (a measure). It is called a weather-glass, because changes of weather are indicated by its varying conditions.

Q. *What is a* THERMOMETER?

A. An instrument to show how *hot or cold* anything is.

THERMOMETER is a compound of two Greek words, Θερμος (heat), and μετρον (a measure).

Q. *What is the* DIFFERENCE *between* THERMOMETER *and a* BAROMETER?

A. In a THERMOMETER the mercury is *sealed up from the air;* and rises or falls, as the varying *temperature* of the air expands or contracts it: but

In a BAROMETER the column of mercury is left *exposed* (or open) to the air, at its *lower extremity;* and rises or falls, as the varying *weight* of the air presses more or less upon it.

Q. *If the mercury of the thermometer be* SEALED UP *from the air, how can the heat* AFFECT *it?*

A. The heat of the air passes *through the glass tube* into the mercury, causing the metal to expand and rise in the tube.

Q. *Why is the tube of a barometer left* OPEN?

A. That the air may *press upon* the exposed surface of the mercury: As this pressure varies, the mercury *rises or falls* in the tube.

The top of the tube must be a "*vacuum;*" otherwise the pressure of the external air upon the lower part of the column would not affect the mercury so freely.

Q. *For what* PRACTICAL PURPOSES *is the barometer used?*

A. 1st—To determine the height of mountains: and

2ndly—To indicate changes of the weather.

The barometer was invented by Toricelli, a pupil of Galileo, 1643.

Q. *How can a* BAROMETER *determine the* HEIGHT *of a mountain?*

A. As the *weight* of air decreases the *higher* we ascend, the mercury of a barometer will gradually *fall* and indicate the *height* of our ascent.

Q. *Does the density or weight of air decrease in any regular proportion?*

A. Yes; the density of air decreases upwards in a regular geometrical series.

Thus at an elevation of 3½ miles, the density of the air is only *half* what it is on the earth's surface: at 7 miles, only *one-fourth*; at 10½, *one-eighth*; at 14 miles, *one-sixteenth*. Though the atmosphere probably extends 45 or 50 miles above the level of the sea, yet at an elevation of 20 miles, it has but little weight.

Q. *What causes the* WEIGHT *of air?*

A. The pressure of superincumbent strata. Thus in a pile of books, the lower volumes sustain the weight of those piled over them.

Q. *How can a barometer which measures the* WEIGHT *of air, be of service as a* WEATHER *glass?*

A. When air is filled with vapour, it is *lighter* than usual; and the column of mercury stands low. When air is dry, and free from vapour, it is heavier than usual; and the mercury stands *high:* Thus the barometer (by shewing the variations in the weight of the air) indicates when it is *moist*, and likely to rain or not.

Q. *Does the* WEIGHT *of the air* VARY MUCH?

A. Yes; the atmosphere in England varies as much as *one-tenth part* more or less.

Q. *Of what* USE *is the* BAROMETER *to sailors?*

A. It warns them to *prepare their ships*, before squalls come on.

Q. *How can a* BAROMETER *warn* SAILORS *to prepare their* SHIPS?

A. As it indicates when *wind*, *rain*, and *storm* are at hand, the sailor can make his ship trim before they come upon him.

Q. *Are there any* RULES, *which can be depended on?*

A. Yes; there are *ten special rules* to direct us how to know the changes of weather, by marking the mercury of a barometer.

Q. *Mention the* 1*st* SPECIAL RULE *with regard to the barometer.*

A. The barometer is *highest of all* during a *long frost;* and it generally rises with a *north-east wind*.

Q. *Why is the barometer* HIGHEST *of all during a long* FROST?

A. Because the air is exceedingly dry: and dry air causes the mercury of a barometer to rise.

Q. *Why does the barometer generally* RISE *with* NORTH-EAST *winds?*

A. Because NORTH-EAST winds make the air both *cold and dry;* and being both *condensed*, and *without vapour*, it is much heavier.

Q. *Mention the 2nd* SPECIAL RULE *with regard to the barometer.*

A. The barometer is *lowest of all* during a *thaw, which follows a long frost;* and it generally falls with SOUTH or WEST wind.

Q. *Why does the barometer fall* LOWEST *of all, at the* BREAKING UP *of a long* FROST?

A. Because the air (which had been much *dried* by the frost) *absorbs the moisture* of the fresh warm current of wind from the south or south-west; and becomes laden with vapour.

Q. *Why does the barometer fall very low with* SOUTH *and* WEST *winds?*

A. Because SOUTH and WEST winds come heavily *laden with vapour:* and *vaporized* air is lighter than *dry* air.

Q. *What effect has* WIND *on the mercury?*

A. The barometer is *high*, when the wind blows between the EAST and the NORTH. But it is *low*, when the wind blows between the SOUTH and WEST.

Q. *What is the 3rd* SPECIAL RULE *with regard to the barometer?*

A. While the barometer stands above 30, the air must be very *dry*, or very *cold*, or perhaps *both*,—and *no rain* may be expected.

Q. *Why will there be* NO RAIN, *if the* AIR *be very* DRY?

A. Because *dry* air will *absorb moisture*, and not part with it in *rain*.

Q. *Why will there be* NO RAIN *if the* AIR *be very* COLD?

A. Because it is *so much condensed*, that it has already parted with as much moisture as it can spare.

Q. *What is the 4th* SPECIAL RULE *with regard to the barometer?*

A. When the barometer stands *very*

low indeed, there will never be *much* rain; although a *fine day* will seldom occur at such times.

Q. *What kind of* WEATHER *is there likely to be, when the barometer is* UNUSUALLY LOW?

A. *Short heavy showers*, with sudden *squalls of wind* from the *west.*

Q. *Why will there be* VERY LITTLE RAIN *if the barometer is* UNUSUALLY LOW?

A. Because the air must be very *warm*, or very *moist*, or perhaps *both.*

Q. *Why will there be little or no rain, if the* AIR *is very* WARM?

A. Because *warm* air has a tendency to *imbibe more moisture*, and not to part with what it has.

Q. *Why will there be little or no rain, if the air be very* MOIST, *and the barometer very* LOW?

A. Because rain will never fall (even tho' the air be saturated) till *cold air* has been introduced to *condense the vapour* And, as soon as *cold* air has been introduced, the barometer will *rise* instantly.

Q. *Name the 5th* SPECIAL RULE *with regard to the barometer.*

A. In summer-time (after a long

continuance of fair weather) the barometer will *fall gradually* for 2 or 3 days before *rain* comes: But if the fall of the mercury is very *sudden, a thunder-storm* may be expected.

Q. *What is the 6th* SPECIAL RULE *with regard to the barometer?*

A. When the sky is cloudless, and seems to promise fair weather,—if the barometer is *low*, the face of the sky will soon be suddenly *overcast.*

Q. *What is the 7th* SPECIAL RULE *with regard to the barometer?*

A. Dark dense clouds will pass over *without rain*, when the barometer is *high:* but if the barometer be *low*, it will often rain *without* any appearance of clouds.

Q. *What is the 8th* SPECIAL RULE *with regard to the barometer?*

A. The *higher* the barometer, the greater the probability of *fair weather.*

Q. *Why is the barometer* HIGH *in* FINE *weather?*

A. Because the air in fine weather contains *very little vapour.* And the *drier* the air, the *higher* does the mercury of the barometer rise.

Q. *What is the 9th* SPECIAL RULE *with regard to the barometer?*

A. When the mercury is in a *rising* state, *fine* weather is at hand: But when the mercury is in a *sinking* state, *foul* weather is near.

Q. *Why does the mercury* RISE *at the approach of* FINE *weather?*

A. Because the air is becoming more *dry*; and, therefore, its *pressure is increased.*

Q. *Why does the mercury* SINK *at the approach of* FOUL *weather?*

A. Because the air is *laden with vapour*, or *disturbed by wind.*

Q. *Why does* VAPOUR *in the air make the mercury* SINK?

A Because vaporized air is *lighter than dry air;* and its *pressure* on the barometer *less.*

Q. *What is the 10th* SPECIAL RULE *with regard to the barometer?*

A. If (in frosty weather) it *begins to snow*, the barometer generally rises to 30; where it remains, so long as the snow continues to fall: If, after this, the weather *clears up*, you may expect *very severe cold.*

Q. *How can you know, if the* MERCURY *of the barometer be* RISING?

A. When the top of the column is *convex*, (i.e. higher in the *middle* than at the *sides*), the mercury is in a *rising state.*

Q. *How can you tell if the* MERCURY *of the barometer be* FALLING?

A. When the top of the column is *concave* (i. e. hollow in the middle), the mercury is in a *falling state.*

Q. *Why is the mercury* CONVEX, *when it is* RISING?

A. Because the parts of the mercury in contact with the *tube* are delayed by the capillary attraction of the glass; in consequence of which, the *middle* part *rises faster* than the *sides;* and the surface is CONVEX.

Q. *Why is the mercury* CONCAVE, *when it is* FALLING?

A. Because the parts of the mercury in contact with the *tube* are delayed by *capillary attraction;* in consequence of which, the *middle* part *sinks faster* than the *sides;* and the surface is CONCAVE.

Q. *What effect does a* THUNDER-STORM *produce on the weather?*

A. It is generally *preceded by hot* weather, and *followed by cold* showery weather.

Q. *What effect does a* SUDDEN CHANGE *of temperature produce on the weather?*

A. A great and sudden change (either from hot to cold, or from cold to hot) is generally followed by *rain within 24 hours.*

Q. *Why is a sudden* CHANGE *from* HOT *to* COLD *followed by rain?*

A. Because cold *condenses the air:* and some of its vapour is given off *in rain.*

Q. *Why is a sudden* CHANGE *from* COLD *to* HOT *followed by rain?*

A. Because the air is quickly *saturated* with *moisture:* but when *night* comes on, and *chills* the temperature, some of the abundant moisture is given off in rain.

Q. *Why is the air quickly* SATURATED *with* MOISTURE, *when* HEAT *rapidly succeeds to* COLD?

A. Because the evaporation (which was checked by the cold) is *carried on very rapidly* in consequence of the increase of temperature.

Q. *When does the barometer* VARY MOST?

A. In winter time.

Q. *Why does the barometer vary* MORE *in* WINTER, *than in* SUMMER *time?*

A. Because the *difference* of temperature between the torrid and temperate zones is much *greater* in winter than in summer; and produces a greater disturbance in the state of the air.

Q. *When does the barometer* VARY LEAST?

A. In summer time.

Q. *Why does the barometer vary* LESS *in* SUMMER, *than in* WINTER?

A. Because the temperature of our island in summer is more *nearly equal* to that of the torrid zone, and its state is *not so much* disturbed by interchange of currents.

Q. *Have* HEAT *and* COLD *any effect on the barometer?*

A. No, not of themselves; but as *cold* weather is generally *dry*, or accompanied with north-east winds, therefore the mercury *rises* in cold weather: And as warm weather is generally *moist*, and accompanied by south-west winds, therefore the mercury *sinks* in warm weather.

Q. *Why is the mercury of a barometer* LOWER *in the* TORRID, *than in the* FRIGID *zone?*

A. Because the warm air of the torrid zone contains much more *vapour*, than the condensed air of the frigid zone; and the *moister* the air, the *less* is its pressure.

Q. *In what* MONTHS *is the barometer* HIGHEST?

A. In May and August; then in June, March, September, and April.

Q. *In what* MONTHS *is the barometer* LOWEST?

A. In November and February: then in October, July, December, and January.

Q. *What are the* DRIEST *months?*

A. March and June; then May and August; then April and November.

Q. *What are the* WETTEST *months?*

A. October and February; then

July and September; then January and December.

Q. *Why is there* LESS *wet from* MARCH *to* AUGUST, *than there is from August to March?*

A. Because the heat is *constantly increasing;* and the capacity of air to absorb and retain moisture increases likewise.

Q. *Why is there* MORE *wet from* AUGUST *to* MARCH, *than from March to August?*

A. Because the heat is *constantly decreasing:* and the capacity of air to retain moisture decreases also; so that (although it often rains) yet the air is always on the point of saturation.

Q. *What does a* SUDDEN *rise or fall of the barometer indicate?*

A. If the *rise* be sudden, fine weather will not continue long.

If the *fall* be sudden, foul weather will not continue long.

Q. *What sort of weather may we expect, if the barometer is very* FLUCTUATING?

A. If the mercury fluctuates much, the weather will be very *changeable* and *unsettled.*

THE FALL OF THE BAROMETER.

In very *hot* weather, the fall of the mercury denotes *thunder*, otherwise, the sudden falling of the barometer denotes high wind.

In *frosty* weather, the fall of the barometer denotes *thaw*.

If *wet* weather happens soon after the fall of the barometer, expect but *little* of it.

In *wet* weather, if the barometer falls, expect much wet.

In *fair* weather, if the barometer falls and *remains* low, expect much wet in a few days, and probably *wind*.

N.B. The barometer sinks lowest of all for wind and rain together; next to that for wind, (except it be an east or north-east wind.)

THE RISE OF THE BAROMETER.

In *winter*, the rise of the barometer presages *frost*.

In *frosty* weather, the rise of the barometer presages *snow*.

If *fair* weather happens *soon* after the rise of the barometer, expect but *little* of it

In *wet* weather, if the mercury rises high and *remains* so, expect continued *fine weather* in a day or two.

In wet weather, if the mercury rises suddenly very high, fine weather will not last long.

N.B. The barometer rises highest of all for north and east wind; for all *other* winds it sinks.

THE BAROMETER UNSETTLED.

If the motion of the mercury be *unsettled*, expect unsettled weather.

If it stand at "MUCH RAIN" and rise to "CHANGEABLE," expect *fair weather of short continuance*.

If it stand at "FAIR" and fall to "CHANGEABLE," expect *foul* weather.

N.B. Its motion *upwards*, indicates the approach of fine weather; its motion *downwards*, indicates the approach of foul weather

CHAPTER XXIV

SNOW. HAIL. RAIN.

Q. *What is* SNOW?

A. The condensed vapour of the air *frozen*, and precipitated to the earth.

Q. *What is the* CAUSE *of* SNOW?

A. When the air is nearly saturated with vapour, and condensed by a current of air, *below freezing point*, some of the vapour is precipitated in a crystalline form as snow.

A few years ago, some fishermen (who wintered at Nova-Zembla), after they had been shut up in a hut for several days, *opened the window;* and the cold external air rushing in, instantly condensed the air of the hut, and its vapour fell on the floor *in a shower of snow.*

Q. *Why does* SNOW *fall in* WINTER *time?*

A. Because the sun's rays are too *oblique* to heat the surface of the earth; and (as the earth has but little heat to radiate into the air) the air is very cold.

Q. *What is the cause of* SLEET?

A. When flakes of snow (in their descent) pass through a bed of air *above* *freezing point*, they partially melt; and fall to the earth as half-melted snow, or sleet.

Q. *What is the* USE *of* SNOW?

A. To keep the earth *warm*, and to *nourish* it.

Q. *Why does snow keep the* EARTH WARM?

A. Because it is a very *bad conductor;* in consequence of which, when the earth is covered with snow, its temperature very rarely descends *below freezing point*, even when the air is 15 or 20 degrees colder.

Q. *Tell me the words of the* PSALMIST (cxlvii. 16) *respecting snow; and explain what he means.*

A. The Psalmist says—"The Lord giveth snow like wool;" and he means not only that snow is *white like wool*, but that it is also *warm as wool.*

Q. *Why is* WOOL WARM?

A. Because *air* is entangled among the fibres of the wool: and air is a very *bad conductor.*

Q. *Why is* SNOW WARM?

A. Because *air* is entangled among the crystals of the snow; and air is a very *bad conductor.*

Q. *Why does* SNOW NOURISH *the earth?*

A. Because it supplies *moisture* containing carbonic acid; which penetrates slowly into the soil, and insinuates itself through every clod, ridge, and furrow, when the snow melts.

Q. *Why is there* NO SNOW *in* SUMMER *time?*

A. Because the *heat of the earth* melts it in its descent, and prevents it from reaching the surface of the earth.

Q. *Why are some* MOUNTAINS ALWAYS COVERED *with* SNOW?

A. 1st—Because the *air* on a high mountain is more *rarefied;* and as rarefied air retains much heat in a latent state, it abstracts heat from adjacent bodies more rapidly than condensed air would: and

2ndly—Mountain tops are not *surrounded by earth*, to radiate heat into the air: and, therefore, the snow is *not melted* in its descent, but falls on the mountain and lies there.

Q. *Why is* SNOW WHITE?

A. Because it is formed of an infinite

number of very minute crystals and prisms, which reflect all the component rays of which white light consists.

The same answer applies to salt, loaf sugar, &c. (*See p.* 419.)

Q. *What is* HAIL?

A. Rain, which has passed in its descent *through a cold bed of air*, and has been frozen into ice.

Q. *What makes* ONE *bed of air* COLDER *than another?*

A. The causes are not perfectly known; *electrical action* is most probably among them.

Q. *Why is* HAIL *frequently accompanied with* THUNDER *and* LIGHTNING?

A. 1st—Because the *congelation of water into hail*, disturbs the electricity of the air: and

2ndly—The *friction* (produced by the fall of hail) may possibly excite it still more.

Q. *Why does* HAIL *fall generally in* SUMMER *and* AUTUMN?

A. 1st—Because the air is *more highly electrified* in summer and autumn, than in winter and spring: and

2ndly—The vapours in summer and autumn (being rarefied) ascend to more elevated regions, which are *colder* than those nearer the earth.

Q. *What* TWO *things are essential to cause* HAIL?

A. Two *strata of clouds* having *opposite electricities*, and *two currents of wind.* The *lower cloud* containing resinous electricity, is the one *precipitated* in hail.

Q. *What is* RAIN?

A. The vapour of the clouds or air *condensed*, and precipitated to the earth.

Q. *When is the vapour of the air or clouds* PRECIPITATED *in hail, rain, or snow?*

A. When the air is *saturated with vapour*, and a cold current *condenses* it, it is then no longer able to hold all its vapour in solution, and some of it falls as rain.

Q. *Why does* RAIN *fall in* DROPS?

A. Because the vapoury particles in their descent *attract each other;* and those which are sufficiently near, *unite*, and form into drops.

Q. *Why does not the* COLD *of* NIGHT ALWAYS *cause rain?*

A. Because the air is not always near saturation: And unless this be the case, it will be able to hold its vapour in solution, even after it has been condensed by the chilly night.

Q. *Why does a* PASSING CLOUD *often drop* RAIN?

A. Because it comes in contact with *cold air*, which *chills it;* and its vapour being condensed, falls to the earth as *rain.*

Q. *Why are* RAIN-DROPS *sometimes much* LARGER, *than at* OTHER *times?*

A. Because the rain-cloud is floating *near the earth;* when this is the case, the drops are large, because such a cloud is much more *dense*, than one more elevated.

The size of the rain-drop is also increased, according to the *rapidity* with which the vapours are condensed.

Q. *Does not* WIND *sometimes* INCREASE *the* SIZE *of rain-drops?*

A. Yes; by blowing two or more drops into one.

Q. *Why do* CLOUDS FALL *in* RAINY *weather?*

A. 1st—Because they are *heavy* with abundant vapour: and

2ndly—The density of the air being *diminished*, is less able to buoy the clouds up.

Q. *How do you* KNOW, *that the* DENSITY *of the air is* DIMINISHED *in* RAINY *weather?*

A. Because the mercury of a barometer *falls.*

Q. *Why is* RAIN-WATER *more* FERTILIZING *than* PUMP-*water?*

A. 1st—Because it contains more carbonic acid: and

2ndly—It contains a small quantity of *ammonia*, with which it supplies the young plants.

Q. *Why does* RAIN PURIFY *the* AIR?

A. 1st—Because it *dissolves* the *noxious exhalations* collected in the air as it falls.

2ndly—It mixes the air of the *upper* regions with that of the *lower regions*. and

3rdly—It *washes the earth*, and sets in motion the stagnant contents of sewers and ditches.

Q. *Why are* MOUNTAINOUS *countries more* RAINY, *than flat ones?*

A Because the *air* (striking against the sides of the mountains) is *carried up the inclined plane*, and brought in contact with the *cold air* of the higher regions: in consequence of which, its vapour is *condensed*, and deposited in rain.

Q. *Why does a* SPONGE SWELL, *when it is* WETTED?

A. Because the water *penetrates the pores* of the sponge by capillary attraction, and drives the particles *further from each other:* in consequence of which, the *bulk* of the sponge is greatly *increased.*

Q. *Why do* FIDDLE-*strings* SNAP *in* WET *weather?*

A. Because the moisture of the air (penetrating the strings) causes them to *swell;* and (as the cords *thicken*) their *tension is increased*, and the strings snap.

Q. *Why does* PAPER PUCKER, *when it is* WETTED?

A. Because the moisture is absorbed *unequally* by the paper, and some parts are more enlarged than others: in consequence of which, the paper *blisters* or *puckers*.

Q. *Why do the weather-toys (called* CAP'U-CHINS) *lift a cowl over the figures in wet weather, and remove it in dry?*

A. Because the cowl of the cap'uchin is attached to a *piece of cat-gut* in such a manner, that when the cat-gut is *shortened by moisture*, it pulls the cowl *up:* but in *dry* weather the *string is loosened*, and the cowl falls down by its own weight.

Q. *In another weather toy, the* MAN *comes out in* WET *weather, and the* LADY *in* FINE; *Why is this?*

A. Because the two figures are attached to a piece of *cat-gut* in such a manner, that when the cat-gut is *moist* it twists the *man out;* but when it is *loosened*, the figures turn in the opposite direction.

Q. *Why are* WET STOCKINGS DIFFICULT *to* PULL ON?

A. 1st—Because the moisture penetrates the threads of the stockings, and causes them to *shrink in size:* and

2ndly—Because the moisture causes the stockings to adhere to our feet.

Q. *Which are the* MOST RAINY *towns in* ENGLAND?

A. Keswick (in Cumberland): and then Kendal, (a market town in Westmoreland.)

In Keswick, about 63 inches of rain fall in a year. In Kendal, 58; Manchester, 38; Liverpool, 34; Dublin and Cambridge, 25; Lincoln, 24; London, 21; and in Paris only 18.

Q. *In which* PART *of the* DAY *does the* MOST RAIN *fall?*

A. More rain falls by *night*, than by day; because the cold night *condenses the air;* and diminishes its capacity for holding vapour in solution.

Q. *Does more rain fall in* SUMMER *or in* WINTER?

A. There are *more rainy days* from September to March: but *heavier* rains between March and September.

Q. *Why are there* MORE RAINY DAYS *from September to March, than from March to September?*

A. Because the temperature of the air is *constantly decreasing;* and as its capacity for holding vapour decreases also.

it is frequently obliged to part with some of its vapour in rain.

Q. *In what* PART *of the* WORLD *does* RAIN *fall* MOST ABUNDANTLY?

A. Near the *equator*; and the quantity of rain *decreases* as we approach the *poles.*

There are fewer rainy *days*, altho' more *rain* actually falls during the wet season of the equator—than falls in twelve months at any other part of the globe.

CHAPTER XXV.

WATER.

Q. *Of what is* WATER *composed?*

A. Of *two gases*, oxygen and hydrogen.

In 9 lbs. of water—8 are oxygen, and one is hydrogen.

Q. *Why is* WATER FLUID?

A. Because its particles are kept separate by *latent heat*: When a certain quantity of this latent heat is driven out, *water becomes solid*, and is called ice.

By increasing its *latent heat*, the particles of water are again subdivided into *invisible steam.*

Q. *Why is* PUMP *water called* "HARD *water?"*

A. Because it is laden with foreign matters, and will not readily *dissolve substances* immersed in it.

Q. *What makes* PUMP-*water* HARD?

A. When it filters through the earth it becomes impregnated with the *sulphate and carbonate of lime*, as well as with many other principles derived from the *earths and minerals* with which it comes in contact.

Q. *What is the cause of* MINERAL SPRINGS?

A. When water trickles through the ground, it dissolves some of the substances with which it comes in contact: if the substances are metallic, the water will partake of their mineral character.

Some water is imbued with *lime;* some with *salt*, &c., &c.

Q. *Why is it difficult to* WASH *our* HANDS *clean with* HARD *water?*

A. Because the *soda of the soap* combines with the *sulphuric acid* of the salts of hard water,—and the *oil of the soap* with the *lime*—and floats in flakes on the top of the water.

N.B.—Sulphate of lime consists of sulphuric acid and lime.

Q. *Why is it difficult to wash in* SALT WATER?

A. Because it contains *saline matters*, which deprive the water of a portion of its solvent power.

Q. *What is the cause of* PETRIFACTIONS?

A. While water flows underground its impurities are held in solution by the presence of carbonic acid; but when the stream reaches the open air, its carbonic acid escapes, and these impurities are precipitated on various substances lying in the course of the stream.

These impurities are especially carbonate of lime and iron.

Q. *Why does a* BLACK HAT *turn* RED *at the* SEA SIDE?

A. Because chloride of iron is formed by chemical action, between the components of iron and the chlorine existing in the dye and sea air; the chloride of iron afterwards decomposes, and forms peroxide of iron, which causes the rusty hue.

Q. *Of what is* SOAP *made?*

A. Of kelp (or the ashes of sea-weed dried and burnt in a pit) mixed with oil or fat.

YELLOW SOAP is made of whale-oil, soda, and resin. SOFT SOAP of oil and potash. HARD SOAP of oil and soda.

Q. *Why does* WATER CLEAN *dirty* LINEN?

A. Because it *dissolves* the stains, as it would dissolve salt.

Q. *Why does* SOAP *greatly* INCREASE *the cleansing power of water?*

A. Because many stains are of a *greasy nature;* and soap has the power of *uniting with greasy* matters, and rendering them soluble in water.

Q. *Why is* RAIN WATER SOFT?

A. Because it is not impregnated with *earths and minerals.*

Q. *Why is it* MORE EASY *to* WASH *with* SOFT *water, than with hard?*

A. Because soft water unites freely with soap, and *dissolves* it; instead of decomposing it, as hard water does.

Q. *Why do* WOOD ASHES *make* HARD *water* SOFT?

A. 1st—A double decomposition takes place: the carbonate of potassa in the ashes, and the sulphate of lime in the water unite, and form into sulphate of potassa and carbonate of lime.

2ndly—Wood ashes convert some of the soluble salts of water into insoluble, and throw them down as a sediment: by which means the water is rendered more pure.

Q. *Why has* RAIN-*water such an* UNPLEASANT SMELL, *when collected in a tub or tank?*

A. Because it is impregnated with *decomposed* organic matters, washed from roofs, trees, or the casks in which it is collected.

Q. *Why does* WATER MELT SUGAR *and* SALT?

A. Because very minute particles of water insinuate themselves into the *pores* of the sugar, by capillary attraction: and unite with the minute atoms of the sugar.

Q. *Why does melted* SUGAR *or* SALT *give a* FLAVOUR *to water?*

A. Because the sugar or salt (being disunited into very minute particles) *floats* about the water, and mixes with it intimately.

Q. *Why does* HOT *water melt sugar and salt* QUICKER *than* COLD *water?*

A. Because the *heat* (entering the pores of the sugar or salt) opens a passage for the water

Q. *Why is* SEA-*water brackish?*

A. Because it holds in solution a quantity of *saline matter*, of which common salt is the principal ingredient.

According to a recent analysis, 1000 grains of sea-water from the British Channel contained 27 grains of common salt, and about 8 grains of other saline matter.

Q. *Why is* NOT RAIN-*water* SALT, *although most of it is evaporated from the* SEA?

A. Because saline matter will not *evaporate:* and, therefore, when sea-water is turned into vapour, its salt is left behind.

Q. *Why does* STAGNANT *water* PUTREFY?

A. Because leaves, plants, insects, &c., are decomposed in it.

Q. *Why is* STAGNANT *water full of* WORMS, INSECTS, *&c.?*

A. Because numberless insects *lay their eggs* in the leaves and plants floating on the surface; these eggs are soon hatched, and produce swarms of worms and insects.

Q. *Why is* FLOWING *water* FREE *from* IMPURITIES?

A. Because its currents carry away all *contaminating substances* to the sea.

as fast as they appear in it; and there they are *diffused* through so *large a mass of fluid*, that they become inappreciable.

Q. *Why does* RUNNING *water* OSCILLATE *and* WHIRL *in its current?*

A. 1st—Because it *strikes* against the *banks*, and is perpetually diverted from its forward motion: and

2ndly—Because the *centre* of a river flows faster than its sides

Q. *Why do the* SIDES *of a river flow more* TARDILY *than its* CENTRE?

A. Because they *rub* against the *banks*, and are delayed in their current by friction.

Q. *Why does* SOAPY *water* BUBBLE?

A. Because soap makes *water tenacious;* and prevents the bubbles from *bursting*, as soon as they are formed.

Q. *Why will not water bubble* WITHOUT SOAP?

A. Because it is not tenacious enough to hold together the *bubbles* that are formed.

Q. *When* SOAP-BUBBLES *are blown from a pipe, why do they* ASCEND?

A. Because they are *filled with the warm breath*, which is lighter than air

CHAPTER XXVI.

ICE.

Q *What is* ICE?

A. FROZEN WATER. When the temperature of the air is reduced to 32 degrees, water will no longer remain in a *fluid state.*

Q. *Why is* SOLID ICE LIGHTER *than* WATER?

A. Because water *expands* by freezing: and as its *bulk* is *increased,* its *gravity* must be less.

Nine cubic inches of water become *ten* when frozen.

Q. *Why do* EWERS BREAK *in a* FROSTY NIGHT?

A. Because the water in them *freezes;* and (*expanding* by frost) bursts the ewers to make room for its increased volume.

Q. *Why does it not expand* UPWARDS *(like boiling water) and* RUN OVER?

A. Because the *surface* is frozen first; and the frozen surface acts as a *plug,* which is more difficult to burst, than the earthen ewer itself

Q. *Why do* TILES, STONES, *and* ROCKS, *often* SPLIT *in winter?*

A. Because the moisture in them *freezes;* and (expanding by frost) *splits the solid mass.*

Q. *In winter-time,* FOOT-MARKS *and* WHEEL-RUTS *are often covered with an icy* NET-WORK, *through the interstices of which the soil is clearly seen,*—WHY *does the water freeze in* NET-WORK?

A. Because it freezes first at the *sides* of the foot-prints: other crystals gradually shoot across, and would cover the whole surface, if the earth did not *absorb* the water, before it had time to freeze.

Q. *In winter time, these* FOOT-MARKS *and* WHEEL-RUTS *are sometimes covered with a perfect* SHEET *of ice, and not an icy net-work,—Why is* THIS?

A. Because the *air is colder*, and the *earth harder*, than in the former case; in consequence of which, the *entire surface* of the foot-print is frozen over, before the earth has had time to absorb the water.

Q. *Why is not the ice* SOLID *in these ruts?* —WHY *is there only a very thin* FILM *or* NET-WORK *of ice?*

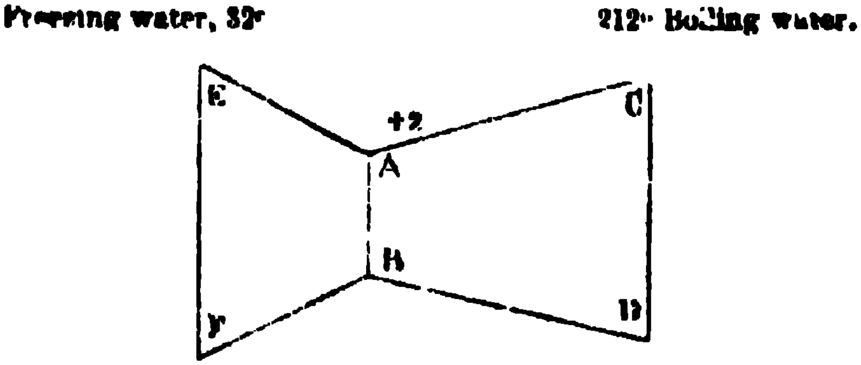
A. Because the earth *absorbs most of the water*, and leaves only the icy *film behind*.

Q. *Why do* WATER-PIPES *frequently* BURST *in* FROSTY *weather?*

A. Because the water in them *freezes;* and (*expanding by frost*) bursts the pipes to make room for its increased volume.

Q. *Does not water expand by* HEAT, *as well as by* COLD?

A. Yes; it expands as soon as it is more than 40 degrees, *till it boils;* after which time it flies off in steam.



Here A B measures the bulk of a portion of water at 40 degrees.
It goes on increasing in bulk to C D, when it boils.
It also goes on increasing in bulk to E F, when it freezes.

Q. *When does* WATER *begin to* EXPAND *from cold?*

A. When it is reduced to 40 degrees. It is wisely ordained by God that water shall be an *exception* to a very general rule, it *contracts* till it is reduced to 40 degrees, and then it *expands till it freezes.*

The general rule is this—That cold *condenses* and *contracts* the volume of nearly every thing; but water is *not contracted* by cold after it has reached 40 degrees.

Q. WHY *does water expand when it freezes?*

A. Because it is converted into *solid crystals*, which *do not fit so closely* as the particles of water did.

Q. *Why is the* BOTTOM *of a river* SELDOM FROZEN?

A. Because water, when it becomes colder than 40 degrees, *ascends* to the surface; and (if it freezes) *floats there*, till it is melted.

Q. *Show the* WISDOM *of* GOD *in this wonderful exception to a general law.*

A. If ice were *heavier than water*, it would *sink;* and a river would soon become a *solid block of ice*, which could never be dissolved.

Q. *Why does not* ICE *on the* SURFACE *of a river* CHILL *the water* BENEATH, *and freeze it?*

A. 1st—Because water is a *very bad conductor*, and is heated or chilled by CONVECTION only: and

2ndly—The ice on the surface acts as a *shield*, to prevent cold air from *penetrating through the river*, to freeze the water below the surface.

Q. *Why does* WATER FREEZE *at the* SURFACE *first?*

A. Because the surface is in *contact with the air*, and the air *carries away its heat.*

Q. *Why does the coat of ice grow* THICKER *and* THICKER, *if the frost* CONTINUES?

A. Because the *heat* of the water (immediately below the frozen surface) *passes through the pores of the ice* into the *cold air.*

Q. *Why are not* WHOLE RIVERS FROZEN *(layer by layer), till they become solid ice?*

A. Because water is so *slow* a conductor, that our frosts never continue *long enough* to convert a whole river into a solid mass of ice.

Q. *Why does not* RUNNING *water freeze so* FAST *as* STILL *water?*

A. Because the rapid motion of the current prevents the *crystals* from forming into a continuous surface.

Q. *When* RUNNING *water is* FROZEN, *why is the* ICE *generally very* ROUGH?

A. Because little flakes of ice are first formed and carried down the stream, till they meet some *obstacle* to *stop* them; then *other* flakes of ice (impinging against them) are arrested in like manner: and the *edges* of the different flakes *overlapping* each other, make the surface *rough.*

Q. *Why do* SOME *parts of a river* FREEZE LESS *than others?*

A. Because *springs* issue from the bottom; and, bubbling upwards, *thaw the ice,* or make it thin.

Q. *When persons* FALL *into a river in winter, why does the* WATER *feel comparatively* WARM?

A. Because the *frosty air* is at least 10 or 12 degrees *colder* than the water.

Q. *Why is* SHALLOW *water* FROZEN *more* QUICKLY *than* DEEP *water?*

A. [*]Because the *whole volume* of water must be cooled to 40 degrees, before its *surface* can be frozen: and it takes a longer time to cool down a *deep* bed of water, than a *shallow* one.

Q. *Why is* SEA-WATER RARELY FROZEN?

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[*] The frozen river below its surface is at least 40°; but the air 32°, or even less.

A. 1st—Because the *mass of water is so great*, that it requires a very long time to cool the whole volume down to 40 degrees:

2ndly—The *ebb and flow* of the sea interfere with the cooling influence of the air: and

3rdly—*Salt* water never freezes, till the surface is cooled down 4 or 5 degrees below the freezing point of fresh water.

Q. *Why do some* LAKES RARELY *(if ever)* FREEZE?

A. 1st—Because they are *very deep*: and

2ndly—Because their water is supplied by *springs*, which bubble from the bottom.

Q. *Why does the* DEPTH *of water* RETARD *its freezing?*

A. Because the *whole volume of water* must be reduced to 40 degrees, before the surface will freeze: and the *deeper* the water, the *longer* it will be before the whole volume is thus reduced.

Q. *Why do* SPRINGS *at the bottom of a lake* PREVENT *its freezing?*

A. Because they continually send forth *fresh water*, which prevents the lake from being reduced to the necessary degree of coldness.

Q. *It is* COLDER *in a* THAW *than in a* FROST. *Explain the reason of this.*

A. When frozen water is *thawed*, it *absorbs* heat from the *air*, &c., to melt the ice: in consequence of which, the heat of the air is greatly reduced.

Q. *It is* WARMER *in a* FROST *than in a* THAW. *Explain the reason of this.*

A. When water *freezes*, it gives out *latent heat;* and as much heat is liberated from the water into the atmosphere, the air feels *warmer.* (*See N. B. p.* 32.)

Q. SALT DISSOLVES ICE. *Explain the reason of this.*

A. Water freezes at 32°, but *salt* and water will not freeze till the *air* is 4 or 5 degrees *colder;* if, therefore, salt be added to frozen water, it dissolves the ice.

Q. *Will anything* DISSOLVE ICE *besides* SALT?

A. Yes; any *acid*, such as sulphuric acid, nitric acid, &c.

Anything which has a very strong affinity for water will liquefy ice

Q. *Why is a mixture of* SALT *and* SNOW *colder than* SNOW *itself?*

A. Because *salt dissolves the crystals* of snow into a fluid: And whenever a solid is converted into a fluid, *heat is absorbed*, and the cold made more intense.

Q. *Why does* FROST *make the* EARTH CRACK?

A. Because the water absorbed in warm weather, expanding by the frost, thrusts the particles of earth apart from each other, and leaves a chink or crack between

Q. *Shew the* WISDOM *of* GOD *in this arrangement.*

A. These *cracks* in the earth let in air, dew, rain, and many gases favourable to vegetation.

Q. *Why does the* EARTH CRUMBLE *in* SPRING?

A. Because the *ice* of the clods *dissolves;* and the particles of earth (thrust apart by the frost) being left *unsupported*, tumble into minute parts, as soon as their *cement of ice is dissolved.*

Q. *Why does* MORTAR CRUMBLE *away in* FROST?

A. Because it was not *dried in the*

warm weather: therefore, its moisture *freezes*, *expands*, and thrusts the particles away from each other; but when the frost breaks up, the *water condenses*, and leaves the mortar full of cracks and chinks.

Q. *Why does* STUCCO PEEL *from a* WALL *in* FROSTY *weather?*

A. Because the stucco was not *dried in the warm weather;* therefore, its moisture *freezes*, *expands*, and thrusts the particles away from the wall: but, as soon as the water condenses again from a thaw, the stucco (being unsupported) *falls by its own weight.*

Q. *Why cannot* BRICKLAYERS *and* PLASTERERS *work in frosty weather?*

A. Because *frost* expands mortar, and causes the bricks and plaster to *start from their position.*

Q. *Why do* BRICKLAYERS *cover their work with* STRAW *in spring and autumn?*

A. Because straw is a non-conductor, and prevents the mortar of their new work from *freezing*, during the cold nights of spring and autumn.

Q. *Why are* WATER-PIPES *often covered with* STRAW *in winter-time?*

A. Because straw (being a non-conductor) prevents the *water of the pipes from freezing*, and bursting the pipes.

Q. *Why are delicate* TREES *covered with* STRAW *in* WINTER?

A. Because straw (being a non-conductor) prevents the *sap of the tree* from being frozen.

Q. *Can* WATER *be* FROZEN *in any way* BESIDES *by frosty weather?*

A. Yes; in very many ways. For example—a bottle of water wrapped in *cotton*, and frequently *wetted with ether*, will soon freeze.

Q. *Why would* WATER FREEZE *if a bottle were kept constantly wetted with* ETHER?

A. Because *evaporation* would carry off the heat of the water, and reduce it to *freezing point.*

Q. *Why does* WATER *freeze under the* RECEIVER *of an* AIR *pump, when ether is present and the air exhausted?*

A. Because *evaporation* is very greatly increased by the *diminution of atmospheric* *pressure*; and the ether evaporating very rapidly, produces sufficient cold to freeze the water.

FREEZING MIXTURES.

1. If nitre be dissolved in water, the heat of the liquid will be reduced 16 degrees.
2. If 5 oz. of nitre, and 5 of sal-ammoniac (both finely powdered) be dissolved in 19 oz. of water, the heat of the liquid will be reduced 40 degrees.
3. If 3 lbs. of snow be added to 1 lb. of salt, the mixture will fall to 0° (or 32 degrees below freezing point).

The two following are the coldest mixtures yet known:—

1. Mix 3 lbs. of muriate of lime with 1 lb. of snow.
2. Mix 5 lbs. of diluted sulphuric acid with 4 lbs. of snow.

Ice may be made in a *red-hot* vessel thus. Heat a platinum vessel red-hot, pour into it a little water—then some liquid sulphurous acid: turn the vessel over, and ice will come out. The reason is this, the sulphurous acid so suddenly evaporates from the heat of the vessel, that the water is frozen.

Q. *Why is it more easy to* SWIM *in the* SEA, *than in a* RIVER?

A. Because the *specific gravity of* salt water is *greater*, than that of fresh; and, therefore, it *buoys* up the swimmer better.

Q. *How do cooks ascertain if their* BRINE *be* SALT ENOUGH *for pickling?*

A. They put an egg into the brine. If the egg *sink*, the brine is *not strong enough*; if the egg *float*, it *is*.

Q. *Why will an* EGG SINK *if the brine be* NOT STRONG *enough for pickling?*

A. Because the egg will be the

heavier: but if as much *salt* be added as the water can dissolve, the brine will buoy up the egg, and cause it to float.

Q. *Why will an* EGG FLOAT *in strong* BRINE, *and not in water?*

A Because the specific gravity of *salt and water* is greater than that of water only.

Q. *Why do persons* SINK *in water when they are* UNSKILFUL *swimmers?*

A. Because they struggle to keep their *head out of water.*

Q. *Explain how this is.*

A. When our head is thrown back boldly into the water, our mouth is kept *above the surface*, and we are able to breathe:

But when the head is kept *above the surface* of the water, the chin and mouth sink *beneath* it, and the swimmer is suffocated.

This may be illustrated thus:—If a piece of wood be of such specific gravity, that only *two square inches* can float out of water, it is manifest, that if two *other* inches are raised out, the two *former* inches must be plunged *in*. The body (in floating) resembles this piece of wood—If two square inches of our *face* float out of the water, we can breathe; but if part of the *back* and *crown* of our head be forcibly raised above the surface, a proportional quantity of our face must be plunged *in;* and our mouth becomes covered with water.

Q. *Why can* QUADRUPEDS *swim* MORE EASILY *than* MAN?

A. 1st—Because the *trunk* of quadrupeds is *lighter* than water: and this is the greatest part of them: and

2ndly—The *position* of a beast (when swimming) is a *natural* one.

Q. *Why is it* MORE DIFFICULT *for a* MAN *to swim, than for a* BEAST?

A. 1st—Because his body is more *heavy* in proportion, than that of a beast: and

2ndly—The *position* and muscular action of a *man* (when swimming) differ greatly from his ordinary habits; but beasts swim in their *ordinary* position.

Q. *Why can* FAT *men swim more* EASILY *than* SPARE *men?*

A. Because *fat is lighter than water*, and the *fatter* a man is, the more *buoyant* will he be.

Q. *How are* FISHES *able to* ASCEND *to the* SURFACE *of water?*

A. Fishes have an *air-bladder* near the abdomen; when this bladder is *filled with air*, the fish increases in size; and (being lighter) ascends through the water to its surface

Q. *How are fishes able to* DIVE *in a minute to the* BOTTOM *of a stream?*

A. They *expel the air* from the air-bladder; in consequence of which, their *size is diminished*, and they sink instantly.

CHAPTER XXVII.

LIGHT.

Q. *What is* LIGHT?

A. The unknown cause of VISIBILITY

The most commonly received theory of light is this. A fluid, called the luminous *ether*, fills up the intervening spaces between the several particles of air. This fluid being set in motion, either by some chemical change, by friction, or by some other means, is thrown into a state of *undulation*; and these undulations of ether striking on the optic nerve, make the eye sensible of *light*, in much the same way as undulations of *air* striking on the drum of the ear, give us the sensation of sound. (*See p.* 47.)

Q. *Why can we not see through a* BENT *tube?*

A. Because light propagates itself in *straight* lines, so long as the density of the medium through which it passes is uniform.

Q. *Why does an* OPAQUE *body cast a* SHADOW *behind?*

A. Because it opposes the passage of the light which falls on it, and cannot pass *through it*.

Q. *How do the undulations of ether produce* LIGHT?

A. In the same way as *undulations* of *air* produce *sounds:* i.e. by registering themselves upon the extremities of a nerve prepared for their perception.

The term undulatory is not very correct when applied to the motion of air and ether, in the phenomena of sound and light. It is rather *vibratory* than undulatory.

Q. *How* FAST *does* LIGHT TRAVEL?

A. All light travels so fast, that it would go eight times round the earth, while a person counts "ONE."

All light; whether the light of the sun, the light of a candle, or the *reflected* light of houses, trees, and fields, travels in round numbers 192,000 miles per second.

Q. *Why are* SOME *surfaces* BRILLIANT *(like glass and steel) and others* DULL, *like lead?*

A. Because some surfaces *reflect* much *light*, and are *brilliant;* while others *absorb* a great part of it, and appear *dull.*

Q. *Why can a* THOUSAND *persons* SEE *the* SAME OBJECT *at the same time?*

A. Because it throws off from its surface an infinite number of rays in all directions; and one person sees by *one* portion of these rays, and another person by *another*.

Q. *Why is the eye* PAINED *by a sudden* LIGHT?

A. Because the nerve of the eye is *burdened with rays*, before the pupil has had time to contract.

Q. *Why does it give us* PAIN *if a* CANDLE *be brought suddenly towards our* BED *at night-time?*

A. Because the *pupil* of the eye *dilates* very much in the dark, in order to *admit more rays*. When, therefore, a candle is brought suddenly before us, the enlarged pupils allow the optic nerves to be overloaded *with rays*, and this causes pain.

Q. *Why* CAN *we* BEAR *the candle-light after a few moments?*

A. Because the pupils *contract again* almost instantly; and adjust themselves to the quantity of light which falls upon them.

Q. *Why can we* SEE NOTHING, *when we leave a* WELL-LIGHTED *room, and go into the* DARKER ROAD *or* STREET?

A. Because the pupil (which *contracted* in the bright room) does not *dilate instantaneously*; and the contracted pupil is not able to collect rays enough from the darker road or street, to enable us to see objects before us.

Q. *Why do we* SEE BETTER *when we get* USED *to the* DARK?

A. Because the pupil *dilates* again, and allows more rays to pass through its aperture; in consequence of which, we see more distinctly.

Q. *If we look at the* SUN *for a few moments, why do all other things appear* DARK?

A Because the pupil of the eye becomes so much *contracted* by looking at the sun, that it is *too small* to collect sufficient rays from *other objects* to enable us to distinguish their colours. (*See* "*Accidental colours*;" *pp*. 421, 425.)

Q. *If we watch a bright* FIRE *for a few moments, why does the* ROOM *seem* DARK?

A. Because the pupil of the eye becomes so much *contracted* by looking at the fire, that it is *too small* to collect sufficient rays from the objects around, to enable us to distinguish their colours.

Q. ***Why can we see the* PROPER COLOURS *of every object again, after a few minutes?***

A. Because the pupil dilates again, and accommodates itself to the light around.

Q. ***Why can* TIGERS, CATS, *and* OWLS, *see in the* DARK?**

A. Because they have the power of *enlarging the pupil of their eyes*, so as to collect scattered rays of light more abundantly: in consequence of which, they can *see distinctly* when it is not light enough for us to see *any thing at all.*

Q. ***Why do* CATS *and* OWLS SLEEP *almost all* DAY?**

A. Because the pupil of their eyes is *very broad*, and daylight *fatigues* them; so they close their eyes for relief.

Q. ***Why do* CATS *blink when they sit before a* FIRE?**

A. Because the pupil of their eye is *very broad*, and the light of the fire is painful: so they keep shutting their eyes to relieve the sensation of too much light.

Q. ***Why do* TIGERS, CATS, OWLS, *&c.*, PROWL *by* NIGHT *for prey?***

A. Because they *sleep all day*, when the strong light would be painful to them; and as they can see clearly in the *dark*, they prowl then for prey.

Q. *Why do* GLOW-WORMS *glisten by* NIGHT *only?*

A. Because the light of day is *so* strong as to *eclipse* their feeble light: in consequence of which, they are *invisible by day.*

Q. *Why can we* NOT *see the* STARS *in the* DAY-TIME?

A. Because the light of day is *so* powerful as to *eclipse* the feeble light of the stars; in consequence of which, they are invisible by day.

Q. *Why can we see the* STARS *even at* MID-DAY, *from the bottom of a deep* WELL?

A. Because their light is no longer overpowered by the rays of the sun, which are lost in numerous reflections in the well.

The rays of the *sun* will enter the well very *obliquely*; whereas many *stars* will shine *directly over the well.* (*See pp.* 392, 393.)

Q. *What is the* USE *of* TWO EYES, *since they present only one image of any object?*

A. 1st—To enlarge our field of vision:

2ndly—To increase the distinctness of vision:

3rdly—To diminish the fatigue of vision: and

4thly—To supply the means of sight, if one eye is injured or lost.

Q. *Why do we* NOT *see things* DOUBLE, *with* TWO EYES?

A. Because both images fall on corresponding parts of the two retinæ, which are simultaneously affected.

Persons with oblique vision see double, because both the images looked at, are not painted on points of the retinæ which correspond.

Q. *Why do we* SEE *ourselves in a* GLASS?

A. Because the rays of light from our face, on *striking* against the surface of the glass, are reflected, or sent back again to our eye.

Q. *Why are the rays of light* REFLECTED *by a* MIRROR?

A. Because they cannot *pass through the impenetrable metal* with which the back of the glass is covered: so they *rebound back* again, just as a marble would, if it were thrown against a wall.

Q. *When a marble is rolled towards a wall, what is the path* THROUGH WHICH IT RUNS *called?*

A. The line of INCIDENCE.

Q. *When a marble* REBOUNDS *back again, what is the path it* THEN *describes called?*

A. The line of REFLECTION.

See figure on p. 388. If AB be the line of incidence, then BC is the line of reflection; and *vice versa.*

Q. *When the light of our face goes to the* GLASS, *what is the path through which it goes* CALLED?

A. The line of *incidence.*

Q. *When the light of our face is reflected* BACK *again from the mirror, what is this* RETURNING *path called?*

A. The line of *reflection*

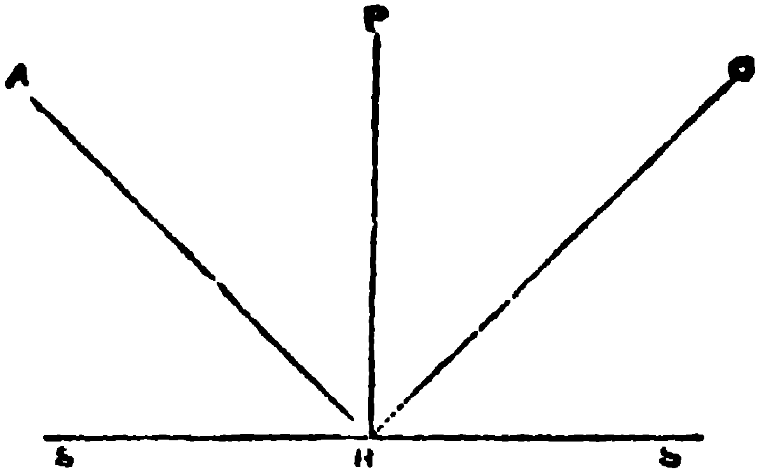
Q. *What is the* ANGLE *of incidence?*

A. The angle between the line of *incidence* and the *perpendicular.*

Q. *What is the* ANGLE *of reflection?*

A. The angle between the line of *reflection* and the perpendicular.

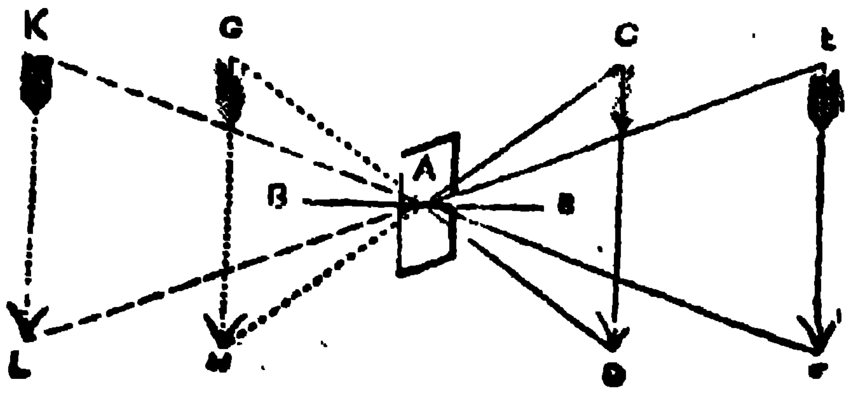
See figure on p. 388



Let SS be any surface, PB a perpendicular to it—If a marble were thrown from A to B, and bounded back to C; then ABP would be called the angle of *incidence*, and CBP the angle of *reflection*.

Q. *Why does our reflection in a mirror seem to* APPROACH *us, as we walk* TOWARDS *it: and to* RETIRE FROM *us, as* WE *retire?*

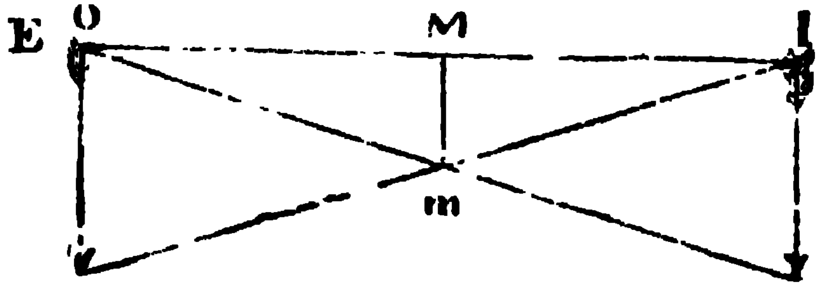
A. Because the *lines* and *angles* of *incidence* are always *equal* to the *lines* and *angles of reflection;* in consequence of which, the *image* will always seem to be as far *behind* the mirror, as the *real object* is *before it.*



Suppose A to be a mirror—CA, EA, DA, and FA the lines of incidence; than GA, KA, HA, and LA, are the lines of reflection. When the arrow is at CD, its image will appear at GH, because line CA=GA, and line DA=HA: and also the angle CAB=angle GAB, and angle DAB=HAB. For a similar reason, if the arrow were at EF, the image would seem to be at KL.

Q. *Why can a man see his* WHOLE PERSON *reflected in a* LITTLE MIRROR, *not* 6 *inches in length?*

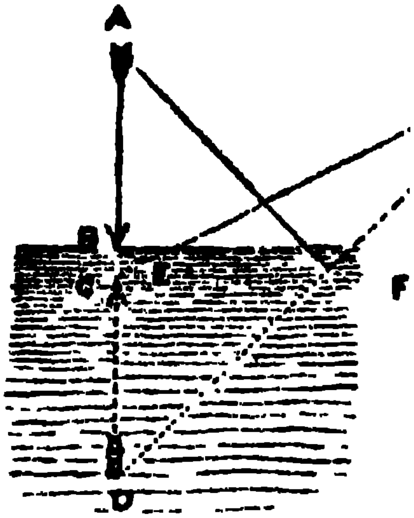
A. Because the *lines and angles* of reflection must be always equal to the *lines and angles of incidence.*



Let M m be a small mirror, and E an eye, looking at I i, an image of the object O o reflected from it Then the ray which falls perpendicularly from O, is reflected back in the same line, so that the image appears as if placed at I. But the ray which falls obliquely from o to m, is reflected by an equal angle to O, and the image seems to be at i, (i. e. in the line of the last reflection). Hence the entire image will appear to be as large as I i.

Q. *Why does the* IMAGE *of any object in* WATER *always appear* INVERTED?

A. Because the *angles of incidence* are always equal to the *angles of reflection.*



Here the arrow head A strikes the water at F, and is reflected as if from D; and the barb B strikes the water at E, and is reflected as if from C.

If a spectator stands at G, he will see the reflected lines CE and DF, produced as far as G.

It is very plain, that A (the more elevated object) will strike the water, and be projected from it more perpendicularly than the point B; and, therefore, the image will seem inverted. *See p.* 388.

Q. *When we see our* REFLECTION *in* WATER, *why do we seem to* STAND *on our* HEAD?

A. Because the *angles of incidence* are always equal to the *angles of reflection.*

The feet are nearest to the surface of the water, and must, therefore, seem so in the reflection; and the head which is more remote, must also seem more distant from the surface of the water which reflects it.

Q. *Why do* WINDOWS *seem to* BLAZE *at* SUN-RISE *and* SUN-SET?

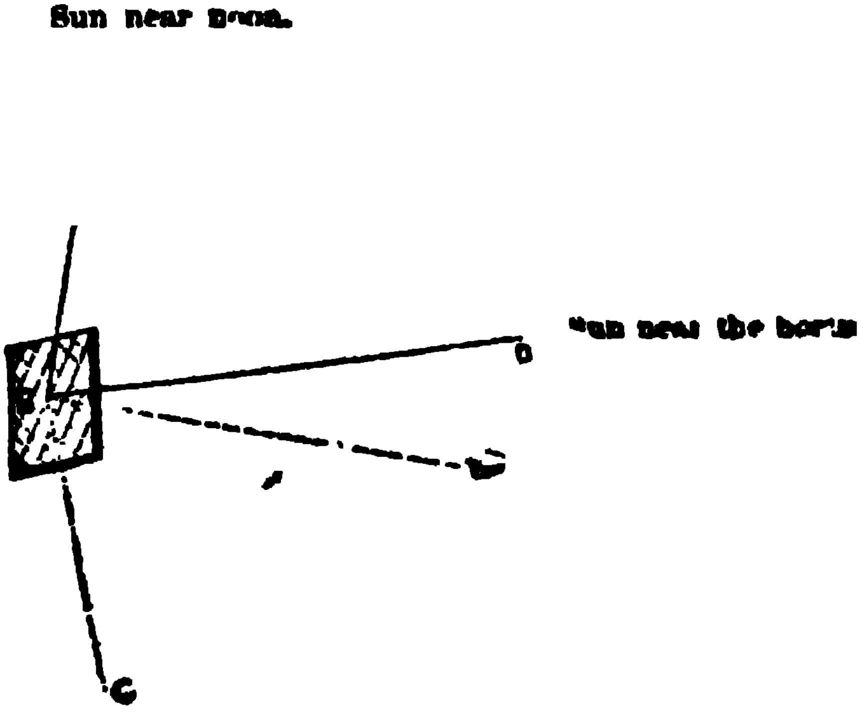
A. Because glass is a good *reflector of light:* and the rays of the sun (striking against the window glass) are *reflected,* or thrown back.

Q. *Why do* NOT *windows reflect the* NOON-DAY *rays also?*

A. They do, but the reflection is *not seen.*

Q. *Why is the reflection of the* RISING *and* SETTING *sun seen in the window, and* NOT *that of the* NOON-DAY *sun?*

A. Because the rays of the noon-day sun glance off from the glass downwards, so that an observer could not readily behold both the window and the sun's reflection.

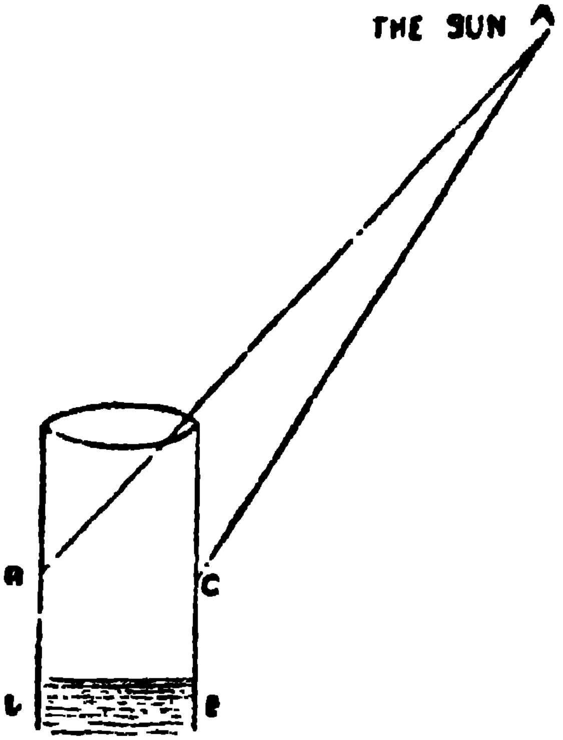


Here AB represents a ray of the noon-day sun striking the window at B; its reflection will be at C:

But DB (a ray of the rising or setting sun) will be reflected to E (the eye of the spectator.)

Q. *Why can we not see the sun's reflection in a* WELL, *during the day-time?*

A. Because the rays of the SUN *fall so obliquely*, that they *never reach* the surface of the water at all, but strike against the brick sides.

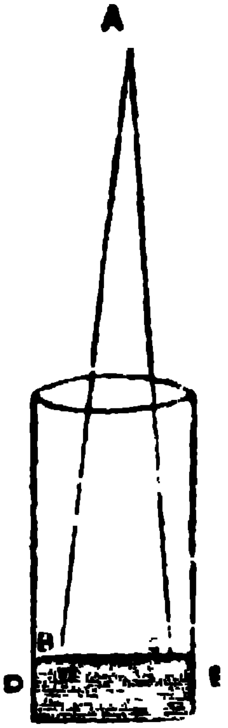


Let BDEC be the well, and DE the water.
The ray AB strikes against the brick-work *inside* the well; and
The ray AC strikes against the brick-work *outside* the well.
None will ever touch the water at DE.

Q. *Why are* STARS *reflected in a* WELL, *although the* SUN *is* NOT?

A. Because the rays of those STARS, which pass nearly *overhead*, will not fall so obliquely into the well, as the rays of the sun.

A STAR.

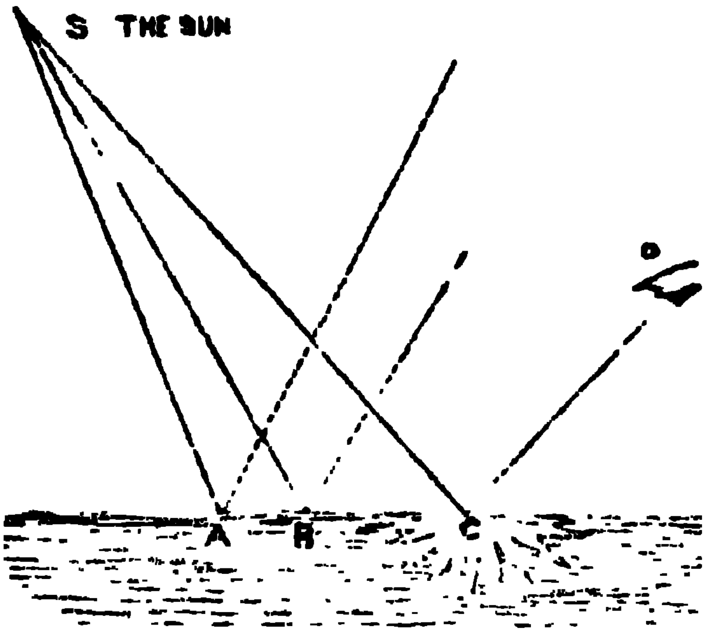


Here the star's rays AB, AC, both strike the water DE, and are reflected by it.

The rays of both sun and moon may be reflected from the surface of water in a well, so placed on the earth's surface, that those luminaries pass vertically overhead (i.e. between the tropics.)

Q. *In a sheet of water at noon, the sun appears to shine upon only* ONE *spot, and all the* REST *of the water seems* DARK,—WHY *is this?*

A. The rays fall at various degrees of obliquity on the water, and are reflected at *similar angles;* but only those which come from the spot where equal angles are formed, between the sun and a perpendicular, and the eye and the same line, are visible as glare.



Here, of the rays SA, SB, and SC, only the ray SC meets the eye of the spectator D. If a line were dropped perpendicularly over C, the angles formed between that line and SC, and DC, would be equal.

The spot C, therefore, will appear luminous to the spectator D, but no other spot of the water ABC.

Q. *Why are* MORE STARS *visible from a* MOUNTAIN, *than from a* PLAIN?

A. Because they have less *air* to pass through. As air *absorbs* and *diminishes* light; therefore, the *higher* we ascend, the *less light* will be absorbed.

Q. *Why do the* SUN *and* MOON *seem* LARGER *at their* RISING *and* SETTING, *that at any other time?*

A. The appearance is an illusion, in consequence of terrestrial objects being placed in close comparison with them at one time and not at the other.

The sun has really the same apparent angular size when on the horizon, and when high in the sky. The moon seems really *smaller* when on the horizon than when high up.

Q. *Why do the* SUN *and* MOON *appear as if flattened into oval forms when seen on the horizon?*

A. Because the lower portions of the disc are more displaced by the refractive power of the atmosphere than the *top*, so that the *vertical diameter* is reduced in length. No such reduction takes place in the *transverse diameter*, therefore the *breadth* seems longer than the depth.

Q. *How does* LIGHT *cause the pupil of the eye to* CONTRACT?

A. The pupil of the eye is a round hole, in the midst of a moveable muscular curtain or screen, called the *iris*. When too much light falls on the nervous retina at the back of the eye, it *irritates* it; and this *irritation* is conveyed to the muscular rings composing the curtain by small nervous fibres, causing them to contract.

The same effect is produced by increasing or diminishing the object aperture of a telescope. The power of a small part of the pupil to allow a perfect but fainter image of an object to be formed, may be thus proved:—Fix the eye attentively upon the flame of a candle, then very slowly advance the edge of a card, held closely to the eye, more and more across the pupil, and the flame will be seen to get fainter and fainter, although it still preserves its perfect outline; at last, it disappears all at once.

Q. *Why can we* NOT SEE *into the* STREET *or road, when candles are lighted?*

A. Because the pupil of the eye (having become *contracted* by the light of the room) is *too small* to collect rays enough from the dark street, to enable us to *see* objects in it.

Q. *Why do we often see the* FIRE REFLECTED *in our parlour* WINDOW *in winter-time?*

A Because glass is a *good reflector*, and the rays of the fire (striking against the window glass) are reflected back into the room again.

Q. *Why do we often see several reflections of our* FIRE *or* CANDLES *in the window, while we are sitting in our parlour?*

A. 1st—Because both surfaces of the window glass reflect them; and

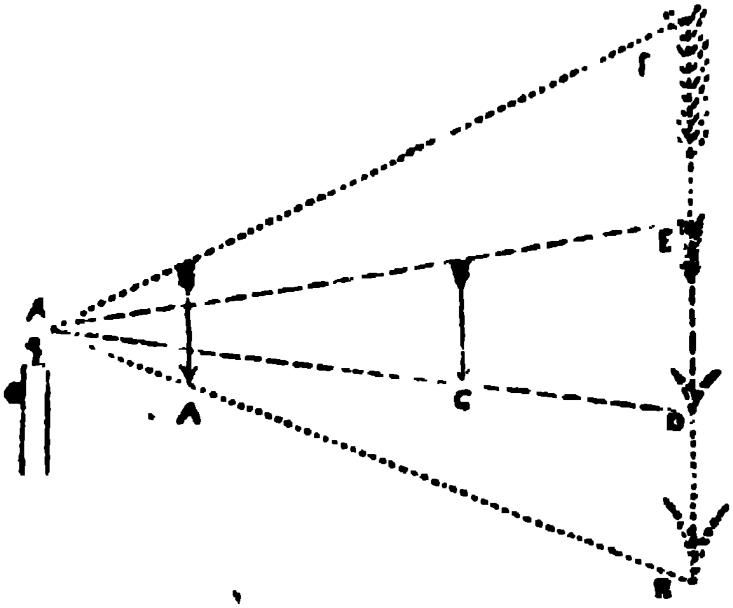
2ndly—The reflections are multiplied by imperfections in the glass.

Q. WHY *is this reflection more clear, if the external* AIR *be* DARK?

A. Because the reflection is not *eclipsed* by brighter rays, passing through *from the other side of the window.*

Q. *If the* SHADOW *of an object be thrown on a wall,—the* CLOSER *the object is held to a* CANDLE, *the* LARGER *will be its* SHADOW. *Why is this?*

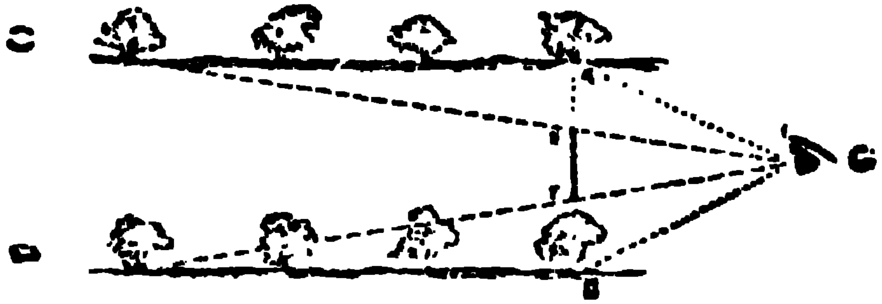
A. Because the rays of light *diverge* from the flame of a candle in *straight lines,* like lines drawn from the centre of a circle.



Here the arrow A held close to the candle, will cast the shadow FB on a wall; while the same arrow held at C would cast only the little shadow DE.

Q. *Why does an* AVENUE *of* TREES, *or a long straight* STREET, *seem to get* NARROWER *and narrower in the distance, till the two sides appear to* MEET?

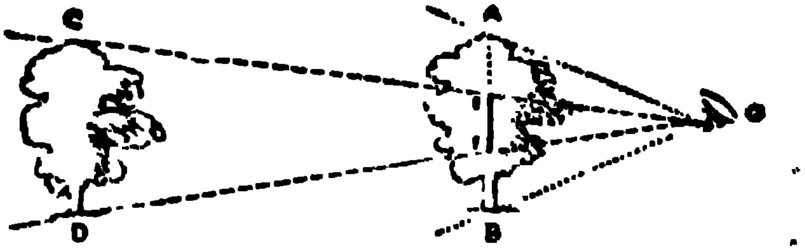
A. Because the *more distant trees or houses are*, the more *acute will be the angle*, that any opposite two make with our eye.



Here the width between the trees A and B will seem to be as great as the line AB:
But the width between the trees C and D will seem to be no more than EF.

Q. *In an* AVENUE *or long straight* STREET, WHY *do* TREES *or houses seem to be* SMALLER *and smaller as their distance increases?*

A. Because the *more distant trees or houses are*, the more *acute will be the angle* made by their perpendicular height with our eye.



Here the first tree AB will appear the height of the line AB; but the last tree CD will appear only as high as the line EF.

Q. *Why do some glasses* MAGNIFY *objects, and others diminish them?*

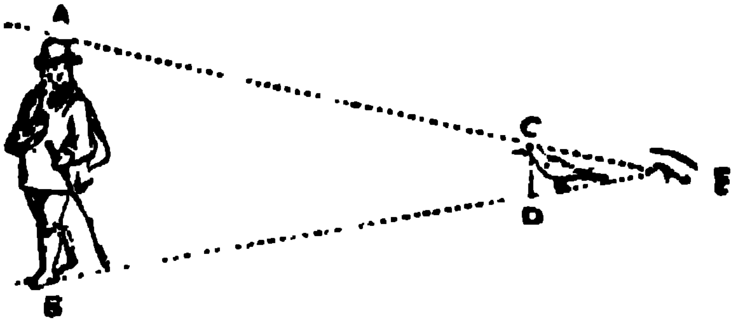
A. This depends upon the *focus* of the glass: if a glass makes the focal distance of an object *longer*, the object appears *diminished* in size: if shorter, it magnifies.

The focal distance means the distance at which the eye perceives an object distinctly. A microscope magnifies by enabling the eye to see an image closer to the eye, than would be possible otherwise.

In the last two figures it is evident--That the larger the angle made by two lines connecting the object with the eye, the larger the object will appear, and *vice versa.* But this angle becomes smaller and smaller as the object is removed further from us. Thus the angle CGD is less than the angle AGB. If a lens therefore *lengthens* the focus, it diminishes objects; if it *shortens* the focus, it magnifies them.

Q. *Why does a man on the* TOP *of a* MOUNTAIN *or church spire, seem to be no* BIGGER *than a crow?*

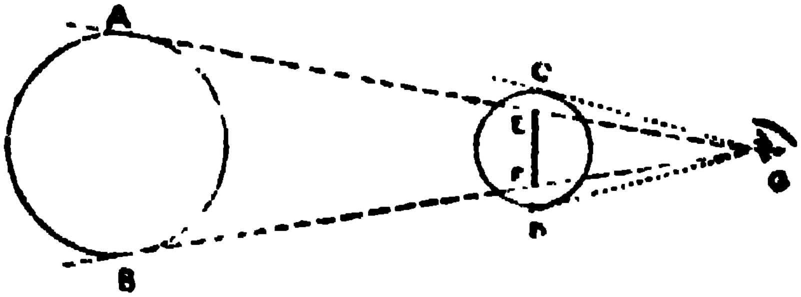
A. Because the angles made in our eye by the *perpendicular height of a man* at that distance, is no bigger than that made by a *crow close by*



Let AB be a man on a distant mountain or spire, and CD a crow close by:
The man will appear only as high as the line CD, which is the height of the crow.

Q. *Why does the* MOON *appear to us so much* LARGER *than the* STARS, *though in fact it is a great deal* SMALLER?

A. Because the moon is *very much nearer to us*, than any of the stars.



Let AB represent a fixed star, and CD the moon.
AB though much the larger body, will appear no bigger than EF: whereas the moon (CD) will appear as large as the line CD to the spectator G.

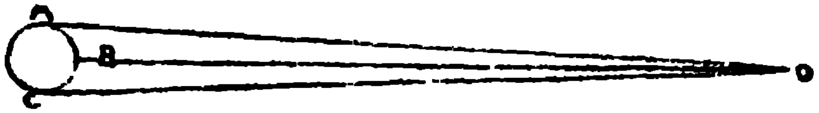
The moon is 240,000 miles from the earth, not quite a quarter of a million of miles The nearest fixed stars are 20,000,000,000,000 (i.e. 20 billions.)

If a ball went 500 miles an hour, it would reach the moon in twenty days; but it would not reach the nearest fixed star in

4,500,000 years. Had it begun, therefore, when Adam was created, it would be no further on its journey, than a coach (which has to go from the Land's End, Cornwall, to the most northern parts of Scotland) after it has passed about three-quarters of a mile.

Q. *Why do the* SUN *and* MOON *(which are spheres) appear to be flat surfaces?*

A. Because they are such an *immense way off*, that we can discern *no difference of length* between those rays which issue from the *edge*, and those which issue from the *centre* of these bodies.



The rays AD and CD appear to be no longer than the ray BD; but if all the rays seem of the same length, the part B will not seem to be nearer to us than A and C; and, therefore, ABC will look like a flat or straight line.

The rays AD and CD, in the case of the moon, are 240,000 miles long.

The ray BD is 238,910 miles long.

Q. *Why does* DISTANCE *make an object* INVISIBLE?

A. Because no *visible perpendicular* can be inserted between the lines which form the angle: or because the *light* has been made very *faint* by the distance.

The image formed within the eye, falls upon so small an area of the internal membrane, that this is not able to affect its perception; or it stimulates the [illegible] so faintly that no sense of sight follows.

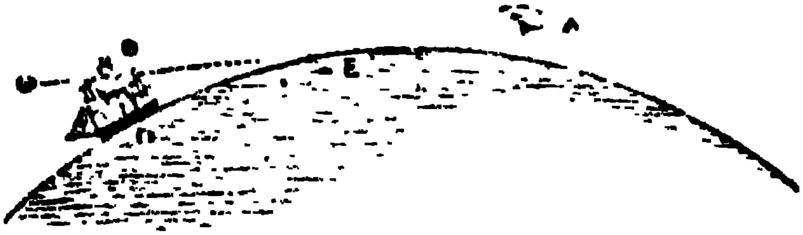
Q. *Why do* TELESCOPES *enable us to see objects* INVISIBLE *to the naked eye?*

A. Because they gather together more luminous rays from obscure objects, than the *eye* can; and form a bright image of them in the tube of the telescope, where they are magnified.

As many times as the dimensions of the *object-glass* exceed the dimensions of the *pupil of the eye*, so many times the penetrating *powers* of the telescope will exceed that of the naked eye.

Q. *When a* SHIP *(out at sea) is approaching shore, why do we* SEE *the small* MASTS, *before we see the bulky* HULL?

A. Because the *earth is round;* and the *curve* of the sea *hides the hull* from our eyes, after the tall *masts* have become visible.



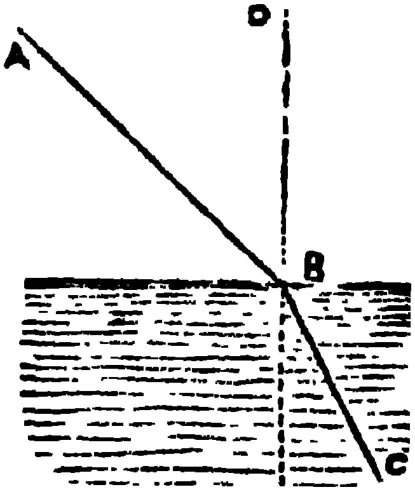
Here only that part of the ship above the line AC, can be seen by the spectator A; the rest of the ship is hidden by the swell of the curve DE.

Q. *What is meant by* REFRACTION?

A. *Bending a ray of light,* as it passes from one medium to another.

Q. How *is a ray of light* BENT, *when it passes from one medium to another?*

A. When a ray of light passes into a *denser* medium, it is bent *towards* the perpendicular. When it passes into a *rarer* medium, it is bent *from* the perpendicular.



Suppose DE to be a perpendicular line.

If AB (a ray of light) enters the water, it will be bent *towards* the perpendicular to C.

If (on the other hand) CB (a ray of light) emerges *from* the water, it would be bent *away from* the perpendicular towards A.

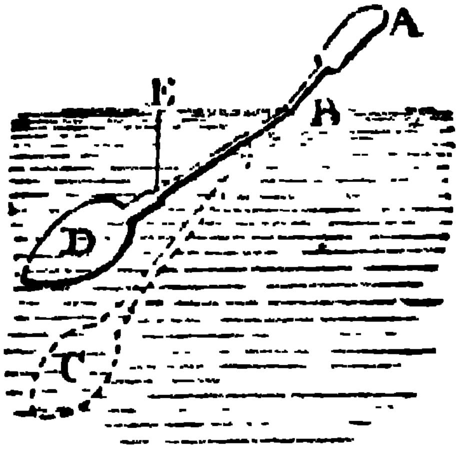
Q.[*] *If light and sound are both produced by oscillations, why can we not* SEE *light, as well as hear sounds, through a bent trumpet or horn?*

A. Because many substances reflect the oscillations of sound, that do not reflect the oscillations of light.

Intervening angles obstruct the passage of sound in some measure, but not to the same extent as they obstruct the passage of light. Thus if a card be placed between a vibrating tuning fork and the air, the sound is dulled. On the other hand, light may be transmitted through a bent tube, if reflecting mirrors are properly placed at th angles.

Q. *Why does a* SPOON *(in a glass of water) always appear* BENT?

A. Because the light (reflected from the spoon) is *refracted*, as it *emerges from the water*.



Here the spoon ABC is refracted, when it enters the water, and appears broken as ABD.

A common experiment, bearing a similar explanation, is this: Put a shilling in an empty basin—move away till you just lose sight of the coin—let some one pour clean water in the basin, and the shilling will again become visible to you.

Q. *Why does a river always appear more shallow, than it really is?*

A. Because the light of the bottom of the river is REFRACTED, as it emerges out of the water.

See fig. on p. 404. The bottom of the river will appear elevated, like the bowl of the spoon D.

Q. *How much deeper is a river, than it seems to be?*

A. About one-third. If, therefore, a river seems only 4 feet deep, it is in reality nearly 6 feet deep.

The exact apparent depth would be $4\frac{1}{2}$. To find the real depth multiply by 4 and divide by 3—thus $4\frac{1}{2} \times 4 \div 3 = 6$ feet real depth.

N.B.—Many boys get out of their depth in bathing, in consequence of this deception. Remember, a river is always one-third deeper than it appears to be:—thus, if a river seems to be 4 feet deep, it is in reality nearly 6 feet deep, and so on.

Q. *Why do fishes seem to be nearer the surface of a river, than they really are?*

A. Because the rays of light from the fish are *refracted*, as they emerge from the water: In consequence of which, the fish appear nearer to our eye, than they really are.

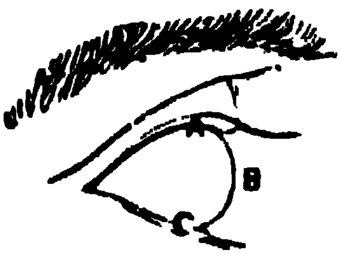
See fig. on p. 404.

Q. *Why are some persons* NEAR-SIGHTED?

A. Because the COR′NEA of their eye is so *prominent*, that the image of distant objects is formed *before it reaches the* RET′INA; and, therefore, is not distinctly seen.

Q. *What is meant by the* "COR'NEA *of the* EYE?"

A. All the *transparent* part of the front of the *eye-ball.*



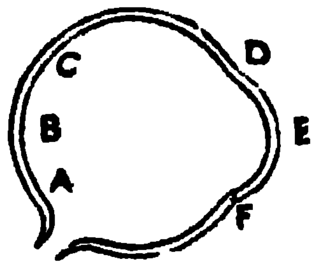
The curve ABC is called the COR'NEA.

If this curve be too prominent (or convex), the eye is near-sighted.

If too flat (or concave), the eye is far-sighted.

Q. *What is meant by the* "RET'INA *of the* EYE?"

A. The net-work, which lines the *back of the eye*, is called the retina.



The net-work ABC is called the ret'ina, and the projecting part DEF is called the cor'nea.

N.B.—This net-work is composed of a spreading out of the fibres of the nerve of vision.

The eye is covered with a tough pearly opaque membrane, called the *sclerot'ric* coat, going all round the eye except over the front DEF (the cornea); at D and F it terminates and makes a groove, into which the transparent cornea fits, just as a watch glass fits into the metal rim made to receive it.

The opening just below A is the optic nerve, which enters the eye on that side nearest the nose; and after it gets into the eye, expands into the lining called the retina.

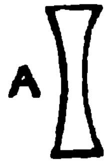
Q. *What sort of* GLASSES *do* NEAR-SIGHTED *persons wear?*

A. If the cor'nea be *too convex* (or

projecting), the person must wear double *concave glasses*, to counteract it.

Q. *What is meant by* "DOUBLE CONCAVE GLASSES?"

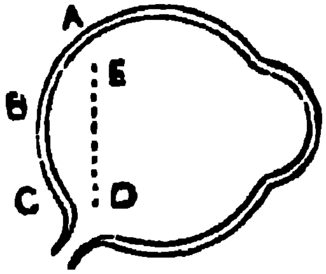
A. Glasses hollowed-in *on both sides.*



The figure A is double concave, or concave on both sides.

Q. *Where is the* IMAGE *of objects formed, if the cornea be too convex?*

A. If the cor'nea be *too convex*, the image of a distant object is formed in the *vitreous humours* of the eye, and not on the *ret'ina.*



Thus the image is formed at DE; and not on ABC (the retina).

Q. *What is the use of* DOUBLE CONCAVE SPECTACLE *glasses?*

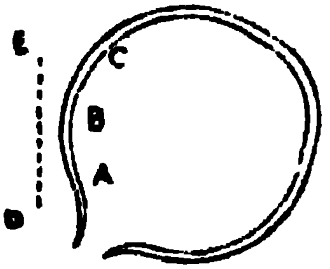
A. To *cast* the *image further back;* in order that it may be thrown upon the retina and become visible.

Q. *Why are* OLD *people* FAR-SIGHTED?

A. Because the humours of their eyes are *dried up by age:* in consequence of which, the COR'NEA *sinks in*, or becomes flattened.

Q. *Why does the* FLATTENING *of the* COR'NEA *prevent persons seeing objects which are* NEAR?

A. Because the cornea is *too flat;* and the image of any near object is not *completely* formed, when rays reach the RETINA; in consequence of which, the image is imperfect and confused.



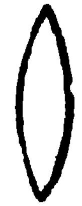
The perfect image would be made at DE; and not on ABC (the retina).

Q. *What sort of* GLASSES *do* OLD *people* WEAR?

A. As their cornea is *not sufficiently convex*, they must use *double convex glasses*, to enable them to see objects near at hand.

Q. *What sort of glasses are* "DOUBLE CONVEX SPECTACLE GLASSES?"

A Glasses which *curve outwards*, on both sides.

A 

The figure A is double convex, or convex on both sides.

Q. *What is the use of* DOUBLE CONVEX *spectacle glasses?*

A. To *shorten the focus of the eye;* and bring the image of distant objects upon the ret'ina.

Q. *Why do* NEAR-SIGHTED *persons bring objects* CLOSE *to the eye, in order to* SEE THEM?

A. Because the refracting powers of *their eye are so great*, that the image of distant objects is formed in *front* of the *ret'ina:* but when objects are brought *near to the eye*, their image is thrown *further back*, and made to fall on the ret'ina.

Because then the rays which come from them to the eye are more divergent, and, therefore, require more refracting power to bring them to a *focus*.

Q. *Why do* OLD *people* HOLD *objects* FAR OFF, *in order to see them better?*

A Because the refracting powers of

their eyes are not great enough: when, however, objects are held further off, it compensates for this defect; and a perfect image is formed on the ret'ina.

Q. *Why are* HAWKS *able to see such an* IMMENSE *way off?*

A. Because they have a muscle in the eye; which enables them to *flatten their cor'nea*, by drawing back the crystalline lens.

There is yet some little uncertainty as to the cause by which the eye is enabled to adapt itself to varying distances.

Q. *Why can* HAWKS *see objects within half-an-inch of their eyes, as well as those a long way off?*

A. Because their eyes are furnished with a flexible bony rim; which can throw the *cor'nea forward*, and make the hawk *near*-sighted (*see p.* 405).

Q. *Into how many* PARTS *may a* RAY *of* LIGHT *be* DIVIDED?

A. Into three parts: BLUE, YELLOW, and RED.

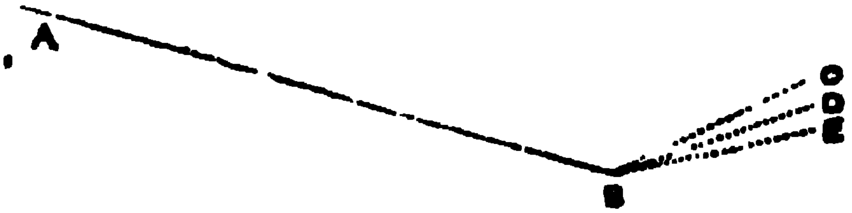
N.B. These three colours, by combination, make seven. 1.—RED. 2.—ORANGE (or red and yellow). 3.—YELLOW. 4.—GREEN (or yellow and blue). 5.—BLUE. 6.—INDIGO (a shade of blue); and 7.—VIOLET (or blue and red).

Q. *How is it known, that a ray of light consists of several different colours?*

A. Because a triangular piece of glass (called a prism), will *divide* it into these seven colours: 1.—Red; 2.—Orange; 3.—Yellow; 4.—Green; 5.—Blue; 6.—Indigo; and 7.—Violet.

Q. *Why does a* PRISM DIVIDE *a ray of light into* VARIOUS COLOURS?

A. Because all these colours have *different refractive susceptibilities.* Red is refracted *least*, and blue the *most:* therefore, the *blue* colour of the ray will be bent to the *top* of the prism, and the *red* will remain at the *bottom*.



Here the ray AB (received on a prism at B), would have the blue part bent up to C the yellow part to D; and the red part no further than E.

Q. *What is meant by the* REFRACTION *of a ray?*

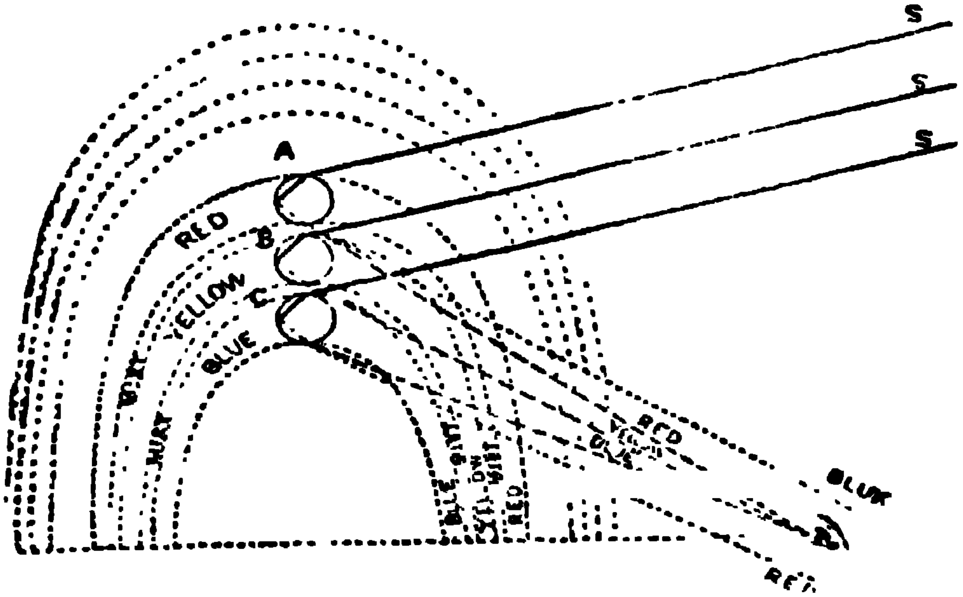
A. *Bending it* from its straight line.

Thus the ray AB of the last figure is refracted at B into three courses, C, D, and E.

Q. *What is the cause of a* RAINBOW?

A. When the clouds opposite the sun

are very dark, and rain is ***still falling*** from them, the rays of the bright sun *are divided into colours by the rain-drops* as they would be by a prism.



Let A, B, and C be three drops of rain; SA, SB, and SC, three rays of the sun. They are all divided into three colours, by the drops of rain on which they fall, and are reflected towards the eye at D.

But since the coloured rays are bent in different degrees, and the drops placed at different heights, only one colour from each enters the eye.

Hence the eye receives the least refrangible (red) from A; the next least (yellow) from B; and the most refrangible (blue) from C. As, however, many drops are similarly circumstanced with regard to the eye, arched bands of colours are visible, constituting the rainbow.

Q. ***Does*** EVERY ***person see the*** SAME ***colours from the*** SAME DROPS?

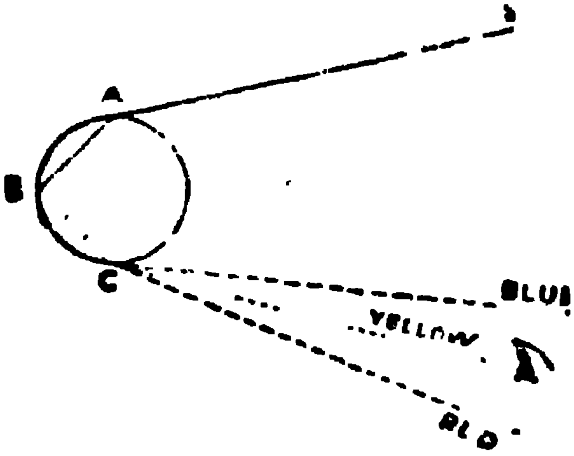
A. No: *no two persons* see *the same rainbow.*

To another spectator the rays from SB might be *red*, instead of yellow: the ray from SC, yellow; and the blue might be reflected from some drop below C. To a *third* person the red may issue from a drop above A, and then A would reflect the yellow, and B the blue, and so on.

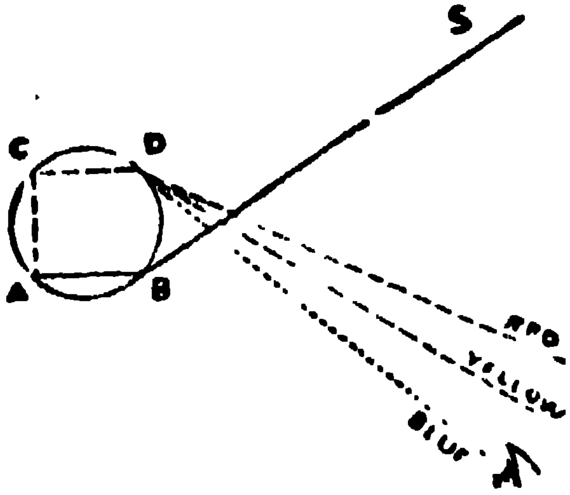
Q. *Why are there often* TWO RAINBOWS, *at one and the same time?*

A. In *one* rainbow we see the rays of the sun *entering the rain-drops at the top*, and reflected to the eye from the *bottom.*

In the *other* rainbow, we see the rays of the sun *entering the rain-drops at the bottom*, and reflected at the top, whence they reach the eye.



Here the ray SA (of the primary rainbow) strikes the drop at A,—is refracted or bent to B,—is then reflected to C, where it is refracted again, and reaches the eye of the spectator. (*See p.* 414.)



Here the ray SB (of the secondary rainbow) strikes the drop at B, is refracted to A,—is then reflected to C,—is again reflected to D, when it is again refracted or bent, till it reaches the eye of the spectator.

Q. *Why are the* COLOURS *of the* SECOND *bow all* REVERSED?

A. Because in *one* bow we see the rays, which enter at the *top* of the rain-drops, *refracted from the bottom;*

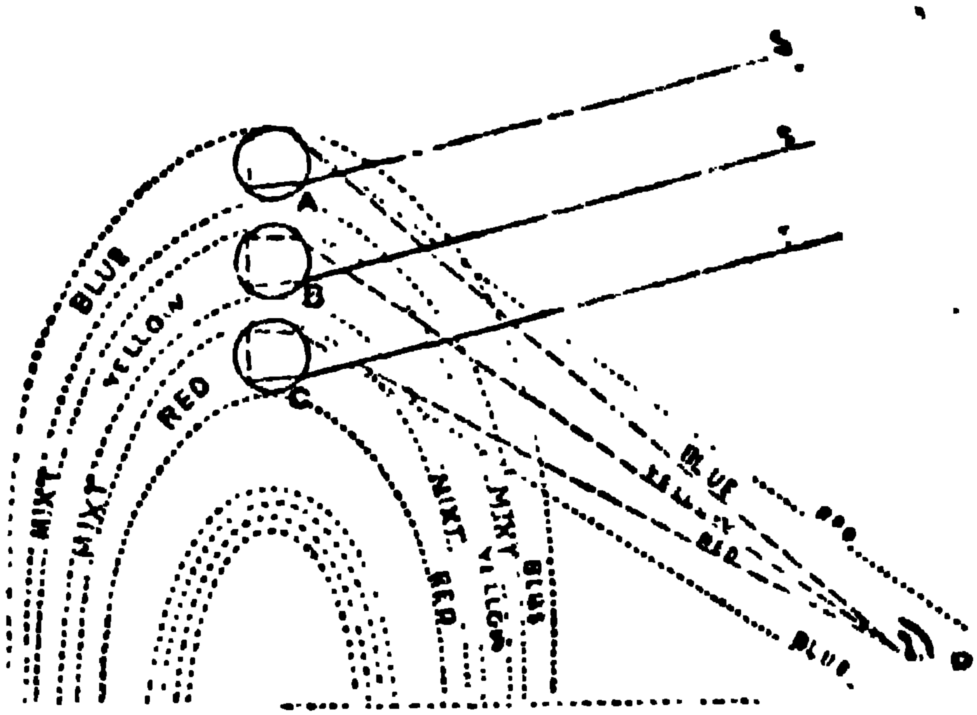
But in the *other* bow we see the rays, which enter at the *bottom* of the rain-drops (after two reflections) *refracted from the top.*

See figure on next page.

Here ABC represent three drops of rain in the SECONDARY (or upper) RAINBOW.

The *least* refracted line is RED, and BLUE the *most*.

So the BLUE (or *most* refracted rays) of all the drops in the position of A,—the YELLOW of those in the position of B, and the RED (or the



least refracted rays) of the lowest drops, all meet the eye D, and form a rainbow to the spectator.

The reason why the primary bow exhibits the stronger colours is this—because the colours are seen *after one* reflection and *two* refractions: but the colours of the secondary (or upper) rainbow, undergo *two* reflections and *two* refractions.

(*See figure on p* 412.) Here also the *least* refracted ray is RED, and the *most* refracted BLUE (as in the former case); but the position of each is reversed.

Q. *Why does a* SOAP BUBBLE *exhibit such a* VARIETY *of* COLOURS?

A. Because the *thickness of the film* through which the rays pass, is constantly varying.

Q. *Why does the* THICKNESS *of the* FILM *affect the* COLOUR *of a soap bubble?*

A. Because different *degrees of thickness* in the film produce different *powers of refraction;* and, therefore, where the *thickness* of the film varies, different colours reach the eye.

Where a spot on the bubble grows excessively thin, it appears black, because it then transmits all the light and reflects none.

Q. *Why is a* SOAP BUBBLE *so constantly* CHANGING *its* THICKNESS?

A. Because water *runs down from the top* to the bottom of the bubble, till the crown becomes so *thin* as to burst.

Q. *Why are* SOME *things* TRANSPARENT?

A. Because they are so constituted as to allow the vibrations of light to be uniformly transmitted through their substance.

Q. *Why are some things* NOT TRANSPARENT?

A. Because they are so constituted as not to allow the vibrations of light to be transmitted through their substance.

Therefore they are seen by light reflected back from them, instead of allowing other bodies to be seen by light transmitted through them.

Q. *Why are* DRY PAPER *and calico (which are* OPAQUE) *made transparent by being* OILED?

A. Because the pores are filled by the oil, which has a different refractive power to the substance of the paper itself:—by this means the substance acquires the property of transmitting vibrations of light.

Q. *Why are* SOME *things* SHINING, *and others* DULL?

A. Because some things *reflect* rays, and are *bright;* but others *absorb* them.

Q. *Why do* DESERTS DAZZLE *from sunshine?*

A. Because each grain of sand *reflects the rays of the sun*, like a mirror.

Q *Why are the* EDGES *of* CLOUDS *more* LUMINOUS, *than their* CENTRES?

A. Because the *body of vapour* is *thinnest* at the edges of the clouds.

Q. WHY *is a ray of* LIGHT *composed of* VARIOUS COLOURS?

A. To vary the colour of different objects. If solar light were *of one uniform colour*, all objects would appear of *that one colour*, or else black.

Q. *Some things are of* ONE COLOUR, *and some of* ANOTHER. *Explain the cause of this.*

A. Every ray of light is composed of

all the colours of the rainbow; and *some* things reflect *one of these colours*, and some *another*.

Q. WHY *do some things reflect* ONE COLOUR, *and some* ANOTHER?

A. Because the *surface* of things is *differently constructed*, both physically and chemically.

As the thickness of a cord affects the tone of it, so the thickness of a lamina affects its colour, as may be seen in a soap bubble. *Thin tight* cords produce sharp shrill sounds, and thin laminæ produce *blue* and *violet* colours. *Thick loose* cords produce deep bass sounds, and thick laminæ *red* colours.

Q. *Why is a* VIOLET BLUE?

A. Because the undulations of ether, which touch its surface, are thrown back with the utmost rapidity; as the undulations of sound from a very thin tight cord of an Æolian harp.

Blue, or rather purple, is the *high treble* vibration of light, like the upper C in music. In order to produce violet colour, the undulations of ether must be 699 millions of millions per second: and in order to make high C in music, a cord must vibrate 516 times per second.

Q. *Why is a* ROSE RED?

A. Red is the *deep bass* vibration of ether, in which the undulations are as slow as they possibly can be, in order to be apparent

Hence the blind man, who said "the deep blast of a trumpet was scarlet," felt an analogy, which science corroborates.

To produce red, the ether must be jerked off the surface of the body at the rate of 477 millions of millions vibrations in a second: and in order to make low C in music, the air must vibrate only 256 times in a second.

Q. *Why is a* PRIMROSE YELLOW?

A. Yellow is made by the medium vibrations, as the middle C in music.

Q. *Why are some things* BLACK, *like coals?*

A. Because their surface will not reflect the undulations of ether which touch it: in consequence of which, they cease.

These surfaces are to *light*, what insonorous substances are to *sound*.

Q. *Why are some things* WHITE, *like a lily?*

A. Because their surface is so constructed as to set in motion the undulations of ether, so that all the rays are reflected together, as harmonious tones in a full chord of music.

Q. *Why are* FROTH, SPRAY, *many* CLOUDS, FAT, LIME, THREAD, *&c., &c., white?*

A. Because they consist of an infinite number of little particles piled one upon another, which are able to reflect all the coloured rays,

Q. *Why are* BONES *white?*

A. Because they are composed of very small straight pipes, capable of reflecting all the colours together: 600 would be no thicker than a hair.

On the colour of snow, sugar, salt, &c., see p. 351.

Q. *Why are the* LEAVES *of plants green?*

A. Because a peculiar chemical principle, called cho'rophyll, is formed within their *cells*.

Chlorophyll χλωρὸν φύλλον, (*a green leaf*) is the green matter of vegetable substances. *Pronounce* klo'-ro-fill.

Q. *Why are leaves a* LIGHT *green in* SPRING?

A. Because the chlo'rophyll is not fully formed.

Q. *Why do leaves turn* BROWN *in* AUTUMN?

A. Because the chlo'rophyll undergoes *decay;* and is not replaced as it is in spring.

Q. *Why are plants a* PALE YELLOW, *when kept in the* DARK?

A. Because chlo'rophyll can be formed only by the agency of the *sun's rays*.

Q. *Why are* POTATOES YELLOW?

A. Because they are grown *underground:* and therefore, can form no chlo'rophyll in their tubers

Q. *Why are potatoes (which grow* EXPOSED *to the air and light)* GREEN?

A. Because chlo'rophyll is formed in them, under the influence of the sun's light.

Q. *Why do the* STARS TWINKLE?

A. Because rays of light, proceeding from the same centre of vibration, *destroy each other*, owing to the inequality of their paths, producing recurring periods of *momentary darkness*.

The differing refrangibility of the atmospheric strata passed through, is the principal cause of the inequality in the motion of the successive systems of waves.

The similarity between sound and light has been already adverted to in pp. 418, 419.—In this particular we find another forcible resemblance, viz.:

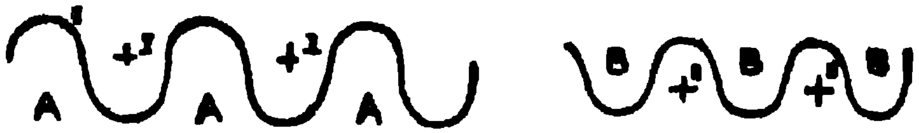
I. TWO SOUNDS INTERCEPTING EACH OTHER'S OSCILLATIONS at opposite phases, will BOTH BE SILENCED.

Vibrate a tuning fork, and hold it over the mouth of a glass beaker, the air will instantly assume sonorous vibrations, and a *tone* will be produced.

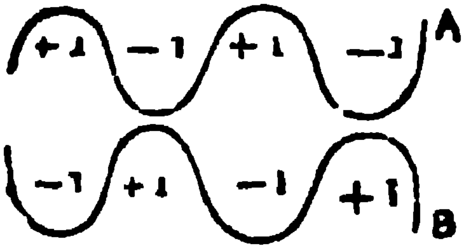
Now hold a beaker at right angles to the other, and the musical tone will instantly cease. Withdraw the second glass, and the tone returns. Hold it again at right angles to the other, and the tone is silenced; and this may be repeated several times.

II. So also TWO RAYS OF LIGHT INTERCEPTING EACH OTHER at opposite phases, will PRODUCE DARKNESS.

Because the depression of one set of waves will be exactly measured by the elevation of the other set, and *vice versa*. To explain this.—

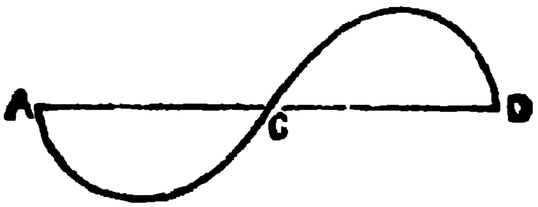


If B were fitted into A, as the depression of B is exactly commensurate with the elevation of A, the two wavy lines would make a level surface.



Again, suppose A the undulations of one star, and B those of another, exactly half a phase different, then it is evident that the elevations and depressions of A would be exactly destroyed by the depressions and elevations of B; and the result of such an interference may be illustrated by the following algebraic formula:

$$\begin{array}{cccc} + & - & + & - \\ - & + & - & + \\ \hline \bullet & \bullet & \bullet & \bullet \end{array}$$



Here A D is a wave, A C one phase, C D its opposite phase.

Q. *If you move a stick (burnt at one end) pretty briskly* ROUND, *it seems to make a* CIRCLE OF FIRE, —WHY *is this?*

A. Because the eye *retains the image*

of any bright object, *after the object itself is withdrawn;* and as the spark of the stick returns *before the image has faded* from the eye, it seems to form a *complete circle.*

Q. *If separate figures (as a man and a horse) be drawn on different sides of a card, and the card* TWISTED *quickly, the man will seem to be seated on the horse,*—WHY *is this?*

A. Because the image of the horse *remains upon the eye,* till the *man* appears.

The Thaumatrope is constructed on this principle; it was invented by Dr. Paris, and consisted at first of a piece of circular card, having two silk strings fastened at the two extremes of its diameter: by twisting the strings, the card is turned round with great rapidity, and the man on one side of the card seems seated on the horse painted on the obverse side. The magnificent conformations of coloured waves, by the same instrument, is a great improvement on the original toy.

Q. *If we look at a* RED-*hot* FIRE *for a few minutes,* WHY *does every thing seem* TINGED *with a* BLUISH GREEN *colour?*

A. Because bluish green is the "ACCIDENTAL COLOUR" of red: If we fix our eye upon *any colour whatsoever,* we see every object tinged with its *accidental colour,* when we turn aside.

"Accidental colour," see note, p 425.

Q. *Why does the eye perceive the* ACCIDENTAL COLOUR, *when the fundamental one is removed?*

A. Because the nerve of the eye has become tired of the one, but still remains fresh for the perception of the other.

Q. *If we wear* BLUE GLASSES, *why does every thing appear tinged with* ORANGE, *when we take them off?*

A. Because *orange* is the "*accidental colour*" of blue: and if we look through *blue glasses*, we shall see its "*accidental colour*," when we lay our glasses aside.

Q. *If we look at the* SUN *for a few moments, every thing seems tinged with a* VIOLET *colour,*—WHY *is this?*

A. Because *violet* is the "*accidental colour*" of *yellow;* and as the sun is *yellow*, we shall see its "accidental colour" *blue*, when we turn from gazing at it.

Q. *Does not the* DARK SHADOW *(which seems to hang over every thing, after we turn from looking at the sun) arise from our eyes being* DAZZLED?

A. Partly so: the pupil of the eye is *very much contracted* by the brilliant light of the sun, and does not adjust itself immediately to the feebler light of terrestrial objects; but, independent of this, the "ACCIDENTAL COLOUR" of the sun being *dark violet*, would tend to throw a shadow upon all things. (*See p.* 383.)

Q. *Why is* BLACK *glass for spectacles the* BEST *for wear, in this respect?*

A. Because *white* is the accidental colour of *black;* and if we wear *black glasses*, every thing will appear *in white light*, when we take them off.

Q. *Why does every thing seem shadowed with a* BLACK MIST, *when we take off our common* SPECTACLES?

A. Because the glasses are *white:* and black being its "accidental colour," every thing appears in a *black shade*, when we lay our glasses down.

The accidental colour of red is bluish green.
" " " of orange " blue.
" " " of violet " yellow.
" " " of black " white.
and the converse of this is true:—
The accidental colour of bluish green is red.
" " " of blue " orange.
" " " of yellow " violet.
" " " of white " black.

(The law of an accidental colour is this—The accidental colour is always half the spectrum. Thus if we take half the length of the spectrum by a pair of compasses, and fix one leg in any colour, the other leg will hit upon its accidental colour.)

N.B.—The spectrum means the seven colours (red, orange, yellow, green, blue, indigo, and violet,) divided into seven *equal* bands, and placed side by side in the order just mentioned.

CHAPTER XXVIII.

SOUND.

Q. *How is* SOUND *produced?*

A. The vibration of some sonorous substance produces a corresponding motion in the air, which strikes upon the *drum of the ear*, and gives the sensation of sound.

Q. *What are* MUSICAL SOUNDS?

A. Regular and uniform successions of vibrations.

Q. *How fast does* SOUND TRAVEL?

A. About 13 miles in a minute, or 1142 feet in a second of time.

Light would go 8 times round the whole earth, while sound is going its 13 miles.

Q. *Why are* SOME *things sonorous, and others* NOT?

A. The sonorous quality of any substance, is connected with its *hardness and elasticity*.

Q. *Why are* COPPER *and* IRON *sonorous, and not* LEAD?

A. Because copper and iron are *hard and elastic;* but lead, being neither hard nor yet elastic, is *not sonorous.*

Q. *Of what is* BELL-METAL *made?*

A. Of *copper and tin* in the following proportions:—In every 5 pounds of bell-metal, there should be 1 lb. of tin, and 4 lbs. of copper.

Q. *Why is this mixture of tin and copper used for* BELL-METAL?

A. Because it is much *harder* and more *elastic,* than any of the pure metals.

Q. *Why is the sound of a bell* STOPPED, *by* TOUCHING *the bell with our finger?*

A. Because the weight of our finger *stops the vibrations* of the bell: and as soon as the bell *ceases to vibrate,* it ceases to make sound-waves in the air.

Q. *Why does a* SPLIT *bell make a hoarse disagreeable sound?*

A. Because the *split* of the bell causes a *double vibration:* And as the sound-waves *clash and jar,* they impede each other's motion, and produce discordant sounds.

Q. *Why do* FIDDLE-STRINGS *give musical sounds?*

A. Because the bow *causes them* to *vibrate;* and this vibration *sets in motion the sound-waves of the air,* and produces musical notes.

Q. *Why does a* DRUM *sound?*

A. Because the parchment head of the drum *vibrates* from the blow of the drum-stick, and sets in motion the sound-waves of the air.

Q. *Why do* MUSICAL GLASSES *give sound?*

A. Because the glasses *vibrate* when they are struck, and set in motion the sound-waves of the air.

Q. *Why do* FLUTES, *&c., produce musical sounds?*

A. Because the breath of the performer causes the *air in the flute* to *vibrate;* and this vibration sets in motion the sound-waves of the air.

Q. *Why do* PIANO-FORTES *produce musical sounds?*

A. Because each *key of the piano* (being struck with the finger) lifts up a little hammer, which *knocks against* a *string;* and the vibration thus produced, sets in motion the sound-waves of the air.

Q. *Why are some notes* BASS, *and some* TREBLE?

A. Because *slow* vibrations produce *bass or deep sounds;* but *quick* vibrations produce *shrill or treble ones.*

The deepest bass sound audible is produced by 32 vibrations in a second, the sharpest treble sound by 15,000.

The note of any higher octave is produced by twice as many vibrations, as the corresponding note of the octave below. Thus if C on the piano be produced by 258 vibrations in a second, then the octave (or eighth note *higher*) would be produced by 516 vibrations in the same time, and the eighth note *lower* by 129 vibrations. (*See p.* 418.)

Q. *Why is an instrument* FLAT, *when the strings are* UNSTRUNG?

A. Because the vibrations being *too slow*, the sounds produced are not *shrill* or *sharp* enough.

Q. *Why can persons, living a mile or two from a town, hear the bells of the town-church* SOMETIMES, *and not at* OTHERS?

A. Because fogs, rain, and snow obstruct the passage of sound; but when the air is *cold and clear*, sound is propagated more easily.

The direction of the wind will often account for this fact.

Q. WHY *can we* NOT *hear sounds (as those of distant church bells) in* RAINY *or snowy weather, so well, as in* FINE *weather?*

A. Because falling rain or snow *interferes with the undulations of the sound-waves*, and stops their progress.

Q. *Why can we* HEAR *distant clocks* MOST *distinctly in clear* COLD *weather?*

A. Because the air is of more *uniform density*, and there are *fewer currents of air*, of unequal temperature, to interrupt the sound-waves.

Besides, dense air can propagate sound-waves more readily than rarer air.

Q. *Why can persons (near the* POLES*) hear the* VOICES *of men in conversation a* MILE *distant in winter time?*

A. Because the air is very *cold*, *clear*, and *still;* in consequence of which, there are but *few currents of air* of unequal temperature to interrupt the sound-waves.

Captain Ross heard the voices of his men in conversation a mile and a half from the spot where they stood; and Lieutenant Foster held a conversation with a man across the harbour of Port Bowen, (in the North Sea,) a distance of a mile and a quarter.

Q. *Why are not* SOUNDS *(such as those of distant church bells) heard so distinctly on a* HOT DAY, *as in frosty weather?*

A. 1st.—Because the density of the air is *less uniform* in very hot weather:

2ndly—It is *more rarefied;* and, consequently, a worse conductor of sound: and

3rdly—It is more liable to *accidental currents*, which impede the progress of sound.

Q. *Why can we not hear sounds (such as those of distant clocks) so distinctly in a thick* MIST *or* HAZE, *as in a clear night?*

A. Because the *density* of the air is not so *uniform* when it is laden with mist; in consequence of which, its *sound-waves* are obstructed in their progress.

Q. *Why do we hear sounds better by* NIGHT, *than by* DAY?

A. 1st—Because night air is of *more uniform density*, and less liable to *accidental currents;* and

2ndly—Night is more *still*. from the suspension of business and the hum of men.

Q. *Why is the air of more* UNIFORM *density by* NIGHT, *than it is by day?*

A. Because the breezes (created by

the action of the sun's rays) generally *cease* at night-fall.

Q. *How should* PARTITION WALLS *be made, to* PREVENT *the voices in adjoining rooms from being heard?*

A. The space between the laths (or canvass) should be filled with *shavings* (or *saw-dust*;) and then no sound would pass from one room to another.

Q. *Why would shavings, or saw-dust,* PREVENT *the transmission of sound from room to room?*

A. Because there would be *several different media* for the sound to pass through: 1st—the air: 2ndly—the laths and paper: 3rdly—the saw-dust or shavings: 4thly—lath and paper again: 5thly—the air again: and every change of medium resists the progress of the *sound-waves.*

Q. *Why can* DEAF *people hear through an* EAR TRUMPET?

A. Because it restrains *the spread of the voice*, and limits the *diameter of the sound-waves;* in consequence of which, their *strength* is increased.

Q. *Why are* MOUNTAINS *noiseless and quiet?*

A. Because the air of mountains is *very rarefied;* and rarefied air is a bad medium for conducting sound.

On the other hand, slight sounds in a diving-bell, when the air is much condensed by the upward pressure of the water, are very intense, and sometimes even painful.

Q. *How do you know, that the rarity of air* DIMINISHES *the intensity of sound?*

A. If a bell be rung in the receiver of an air pump, the sound becomes *fainter and fainter*, as the air is exhausted; till at last it is almost *inaudible.*

Q. *What is the cause of* ECHO?

A. Whenever a sound-wave strikes against any *obstacle* (such as a wall or hill) *it is reflected* (or thrown back); and this *reflected sound* is called an ECHO.

The same laws govern echo as light. (*See p.* 387.)

Q. *What places are most famous for* ECHO?

A. Caverns, grottoes, and ruined abbeys; the areas of halls; the windings of long passages: the aisles of cathedral churches: mountains, and icebergs.

Q. *Why are caverns, and grottoes,* FAMOUS *for* ECHOES?

A. Because the sound-waves which

cannot pass through the cavern or grotto, are driven back again from their sides.

Q. *Why are halls, winding passages, ruins, and cathedral aisles,* FAMOUS *for* ECHOES?

A. Because the sound waves *cannot flow freely forward* in them: but strike against the opposing walls and are beaten *back.*

Q. *Why are* MOUNTAINS *and ice-bergs* FAMOUS *for* ECHOES?

A. Because they present an insurmountable *barrier* to the sound-waves, and *throw them back again.*

Q. *Why do not the* WALLS *of an ordinary* ROOM *or small church produce perceptible* ECHO?

A. Because sound travels with such *velocity*, that the echo is *blended with the original sound;* and the two produce but *one impression* on the air.

Sound travels 13 miles in a minute; and no perfect echo is heard unless the surface (against which the sound strikes) is 65 feet from the place whence the sound originally proceeded.

Q. *Why do very* LARGE *buildings (as cathedrals), often* REVERBERATE *the voice of the speaker?*

A. Because the walls are so *far off from the speaker* that the echo does not *get back in time* to blend with the original sound; and, therefore, *each* is heard separately.

Q. *Why do* SOME *echoes repeat only* ONE *syllable?*

A. Because the echoing body is very *near*. The *further* the echoing body is off, the more syllables it will *reflect:* If, therefore, it be very *near*, it will repeat but one syllable.

Q. *Why does an* ECHO *sometimes repeat* TWO *or more syllables?*

A. Because the echoing body is *far off;* and there is time for one reflection *to pass away*, before *another* reaches the ear.

N.B.—All the syllables must be *uttered* before the echo of the first syllable reaches the ear—If, therefore, a person repeats seven syllables in two seconds of time, and hears them *all* echoed, the reflecting object is 1142 feet distant; (because sound travels 1142 feet in a second, and the words take one second to *go to* the reflecting object, and one second to *return*.)

Q. *Why are* TWO *or more* ECHOES *sometimes heard?*

A. Because separate reverberating surfaces receive the sound, and reflect it in succession.

Seventeen miles above Glasgow (Scotland) near a mansion called Rosneath, is a very remarkable echo. If a trumpeter plays a tune, the echo will begin the same tune and repeat it all accurately :—as soon as this echo has ceased, *another* will echo the same tune in a lower tone; and after the second echo has ceased, a *third* will succeed with equal fidelity, though in a much feebler tone.

At the Lake of Killarney, in IRELAND, there is an echo, which plays an excellent "*second*" to any simple tune played on a bugle.

Q. *Why do* WINDOWS RATTLE *when* CARTS *pass by a house?*

A. 1st—Because glass is *sonorous;* and the air communicates its vibrations to the glass, which echoes the same sound: and

2ndly—The *window-frame* being *shaken*, contributes to the noise.

Window frames are shaken, 1.—By sound-waves impinging against them; 2.—By a vibratory motion communicated to them by the walls of the house.

CHAPTER XXIX.

MISCELLANEOUS.

Q. *Why do the* BUBBLES *in a* CUP *of* TEA *range round the* SIDES *of the* CUP?

A Because the cup *attracts* them.

Q. *Why do all the* LITTLE BUBBLES *tend towards the* LARGE *ones?*

A Because the large bubbles (being the superior masses) *attract them.*

Q. *Why do the* BUBBLES *of a* CUP OF TEA FOLLOW *a* TEA-SPOON?

A. Because the tea-spoon *attracts them.*

Q. *Why are the* SIDES *of a pond covered with* LEAVES, *while the* MIDDLE *of the pond is quite* CLEAR?

A. Because the shore *attracts* the leaves to itself.

If there be any wind stirring, it will drive floating bodies to one side independently of this attractive force.

Q. *Why do all fruits, &c. (when severed from the tree)* FALL *to the* EARTH?

A. Because the earth *attracts* them.

Q. *Why do persons (who water* PLANTS*) very often pour the water into the* SAUCER, *and not over the* PLANTS?

A. Because the water in the saucer is *drawn up* by the mould (through the hole at the bottom of the flower-pot) and transferred through the root to the stem and leaves of the plant by CAPILLARY ATTRACTION. (*See p.* 70.)

Q. *Why is vegetation on the* MARGIN *of a* RIVER *more* LUXURIANT, *than in an open* FIELD?

A. Because the porous earth on the bank *draws up water* to the roots of the plants by CAPILLARY ATTRACTION.

Q. *Why is a* LUMP *of* SUGAR (*left at the bottom of a cup*) *so* LONG *in* MELTING?

A. Because (as it melts) it makes the tea around it *heavier:* and (so long as it remains at the bottom) is surrounded by tea fully *saturated* with sugar; in consequence of which, the *same* portions of liquid will hold *no more sugar in solution.*

Q. *Why does a* LUMP *of* SUGAR MELT *more* QUICKLY, *when* STIRRED ABOUT?

A. Because *fresh portions of unsaturated tea* come in contact with the lump, and soon dissolve it.

Q. *Why does a* PIECE OF SUGAR (*held in a spoon at the* TOP *of our tea*) *melt very* RAPIDLY?

A. Because, as the tea becomes *sweetened*, it *descends to the bottom of the cup* by its own gravity; and *fresh* portions of unsweetened tea are brought constantly into contact with the sugar, till the lump is entirely dissolved.

Q. *How can a* SICK ROOM *be kept* FREE *from unhealthy* EFFLUVIA?

A. By sprinkling it with a solution of chloride of lime.

Q. *Why is* CHLORIDE *of* LIME *used to fumigate a sick room?*

A. Because the chlorine absorbs the *noxious gases of the confined air*; and by this means removes both the *offensive smell* and the *infection* of a sick room.

Q. *Why does* LIME *destroy the offensive smells of* BINS, SEWERS, *&c.?*

A. Because it decomposes the offensive gases upon which the smell depends, and destroys them, by chemical union.

Q. *How can the* TAINT *of* MEAT *be removed?*

A. Either by washing with PYROLIGNEOUS ACID,—or by covering the meat for a few hours with common CHARCOAL, or by putting a *few lumps of charcoal* into the *water in which it was boiled.*

Q. *Why do these things* DESTROY *the* TAINT *of meat?*

A. Because they *combine* with the *putrescent particles*, and neutralize their offensive taste and smell.

Q. *Why should* BED-ROOMS, COTTAGES, HOSPITALS, *and* STABLES, *be washed occasionally with* LIME-WHITE?

A. Because lime *is very caustic*, and removes all organic matters adhering to the walls.

Q. *Why is a* DEAD *man* TALLER *than a living one?*

A. Because at death the CARTILAGES are *relaxed*. So, also, after a night's rest, a man is *taller* than when he went to bed.

Q. *What is* SLEEP?

A. Sleep is the *rest of the brain*, and the sensitive and motor parts of the *nervous system.*

"Motor" (from the Latin *moveo* to move,) those parts which are connected with animal motion.

Q. *Why do we not* SEE, *when we are asleep with our* EYES OPEN?

A. Because the "RETINA of the eye" is *inactive* and at rest. (*See p.* 406.)

Q. *Why do we not* HEAR *in sleep?*

A. Because the nerve of hearing (seated within the TYMPANUM of the ear) is at rest.

Q. *Why do we not* TASTE, *when we are asleep?*

A. Because the nerves *at the end of the tongue* (called papillæ) are inactive and at rest.

Q. *Why do we not* FEEL *when we are asleep?*

A. Because the *ends of the nerves* (called papillæ) situated in the skin, are inactive and at rest.

Some of the phenomena of dreaming seem to show that the functions of the organs of sense are performed. It is the power of perception rather that is dormant.

Q. *Why have persons in sleep no* WILL *of their own, but may be moved at the will of any one?*

A. Because the *entire nervous system*, upon some of whose functions the exercise of will depends, is *inactive* and *at rest.*

Q. *Why has a* DREAMER *no power of* JUDGMENT *or* REASON?

A. Because the *parts* of the brain concerned in the performance of these functions are *inactive* and *at rest.*

Q. *Why does a person* FEEL *when he is* TOUCHED?

A. Because the ends of certain nerves which terminate in the skin, are *excited;*

and this produces a nervous sensation, called FEELING.

The termination of the nerves mentioned are called "Papillæ."

Q. *Why are persons able to* TASTE DIFFERENT FLAVOURS?

A. Because the "PAPILLÆ" of the tongue and palate are *excited* when food touches them; and this produces a nervous sensation, called TASTE.

Q. *What is the use of saliva?*

A. 1st—It mixes *mechanically* with our food, reducing it to a soft pulpy state: and

2ndly—It has certain *chemical* properties, which greatly assist digestion.

Q. *Why does the savour of delicious food make the* MOUTH *of a hungry man* WATER?

A. Because the salivary glands are excited by the savour of the food.

This is a wise provision of God, who thus excites the flow of saliva by the odour of the food, before it is needful to masticate and swallow it.

Q. *Why is* SALIVA *frothy?*

A. Because it contains *air*, in order that it may introduce *oxygen* into the stomach.

APPENDIX OF MISCELLANEOUS QUESTIONS

For the ingenious reader to solve.

The figures refer to the page, where some cognate question may be found

1. Why does *abundance* of dew in the morning indicate that the day will be *fine?* *p.* 211.

2. Why does an *oar* in water appear *bent?* *p.* 404.

3. If a piece of *brown* paper be submitted to the action of a *burning-glass*, it will catch fire much *sooner* than a piece of white paper would: Why so? *p.* 195.

4. Why does a *blue* dress appear *green* by *candle-light?* *p.* 47.

5. Why does the *sun* look *red* in a *fog?* *p.* 145.

6. An *ink-spot* on linen is first *black*, why does it afterwards turn *yellow?* *p.* 419.

7. Why is it dangerous to row a boat under a bridge?

8. Why does a *candle flicker*, especially just previous to its being *burnt out?* *p.* 80.

9. If the "copper" (or boiler) attached to a kitchen range be filled with cold water *after* the fire has been lighted some time, it will very often *burst:* Why? *pp.* 126, 127.

10. Why do all things appear *black* in the *dark?* *p.* 418.

11. Why are the *flag-stones* of our streets frequently *loosened* after a *frost?* *p.* 367.

12. Why is a *room warmer* when the window curtains are drawn? *pp.* 182, 183.

13. Why are rooms much *warmer* for being furnished with *double doors* and *windows* like Kensington Palace? *pp.* 182, 183.

14. Why is *loose* clothing *warmer* than that which fits close? *p.* 183.

15. Why does *wetting a cornelian* make it more *transparent?* *p* 421.

16. Why does *painting* iron prevent it from *rusting?* *p.* 259.

17. Why is a dull *fire revived* by sweeping clean the hobs, bars, ash-grate, &c., of the stove? *pp.* 52, 53.

18. Why does *stirring* a dull *fire* serve to quicken it? *pp.* 52, 53.

19. Why does *soapy* water "lather?" *p.* 365.

20. Why is well-made *bread* full of holes or *eyes?* *p.* 288.

21. Why do the *sails of a wind-mill* turn round? *p.* 113.

22. If you strike a finger-glass, why is the *sound silenced* by *touching* the glass with your finger? *p.* 426.

23. Why does a *wet sponge clean a slate?* *p.* 302.

24. Why do *stars twinkle* more than usual just previous to *rain*? p. 421

25. Why does *milk boil over* more readily than water? *p.* 365.

26. If a *picture* be *glazed*, you cannot see it in certain positions. Why not? *p.* 396.

27. *Dust* very *rarely* flies by night: Why so? *p.* 227.

28. Why does the *cork* of a *soda-water* bottle make a loud report, when drawn? *p.* 108.

29. Why does the *cork* of a *soda-water* bottle *fly* off, as soon as it has been released from the bond which held it in? *p.* 277.

30 Why do our *hands* and *lips chap* in frosty and windy weather? *p* 333.

31. When a *black subsoil* is dug or ploughed up, it turns of a reddish *brown* after a short time: Why is this? *p.* 260.

32. Why are *decaying vegetables* always *wet*? *p.* 284.

33. If a house be faced with *stucco* to resemble stone, why does the facing very often *flake off* in winter, and leave the house unsightly? *p.* 375.

34. Why do the *lustres* of a *chandelier* seem tinted with such *various* and beautiful *colours*? *p.* 411.

35. *Horn* is *transparent*, why are *not* horn *shavings* transparent also? *p.* 416.

36. When a glazier is mending a window, and cleans the pane with his brush, why do the loose pieces of putty (on the *opposite* side of the window-pane) *dance* up and down? *p.* 293.

37. When you rub a piece of paper with *Indian rubber*, why is it *sticky*? *p.* 29.

38. If you dry a piece of common *brown paper* by the fire, and draw it once or twice between your two *knees*, why will it stick fast to the wall? *p.* 29

39. Why can persons be *heard* (in a calm day) at a *greater distance* on the *sea*, than on land? *p.* 430.

40. The *height* of *mountains* may be ascertained by a *barometer*: Explain the reason of this? *p.* 335.

41. How does *starch* assist in giving a smooth *glazed surface* to *linen*? *p.* 421.

42 If a *drop* of *water* be spilt on a table *cloth*, why will it *spread* in all directions? *p.* 76.

43. Why does *salt preserve* meat? *p.* 436.

44. Why does melted *wax* become *hard* when *cold*? *p.* 169.

45. Why does *paint* often *blister* from *heat*? *p.* 375.

46. Why are *rotting leaves hot*? *pp.* 58, 283.

47. Why are *rotting leaves damp*? *p.* 283.

48. Why does *bread* become *hard*, after it has been *kept* a few days? *p.* 169.

MISCELLANEOUS QUESTIONS.

49. Why are *plants white* which are kept in the dark? *p.* 4[illegible].

50. Why does *oil* become *thick* in *winter-time?*

51. Why does a *pop-gun* make a loud *report* when the paper bullet is discharged from it? *p.* 107.

52. Why does *steam* make the engine of a locomotive *whistle?* *p.* 116.

53. Why will *bright iron lose* its *polish*, by being put into a *fire?* *p.* 258.

54. Why does *sound* seem *louder* in *caves* than on a plain? *p.* 431.

55. Why does *paint preserve wood?*

56. Why does *mother* of *pearl* show so many colours?

57. Why can you fill a *dry glass beyond* the level of the brim? *pp.* 436, 437.

58. If you leave a little tea in your cup, and put your spoon in, why does the *tea rush* to the *spoon?* *p.* 436.

59. When *liquor* is poured from a bottle, why does it *gurgle?* *p.* 287.

60. Why will *lucifer matches ignite* by merely drawing them across any rough surface? *pp*, 104, 298.

61. Why will they *not* ignite, if they are *damp?*

62. When our likeness is reflected in a looking-glass, the entire image is *reversed*, our *right* cheek is the *left* cheek of the reflection; if we lift our *right* arm, the reflection moves the *left* arm, and *vice versa:* Why is this? *p.* 388.

63. A *silver* tea-spoon becomes *more heated* by hot tea than one of *inferior* metal (as German silver, Nickel, &c.): Why? *p.* 172.

64 If you scrape a slip of paper with a knife, why will the paper curl?

65. Why does the *stopple* of a decanter *stick fast*, if it be put in damp?

66. Why does the *stopple* of a *smelling bottle* often *stick fast?*

67. Decaying vegetables are first of a brownish tint, why do they afterwards turn of a *deep black?*

68. Why is an *oak* struck by lightning more frequently than any other tree?

69. Why does a *lobster*, which is *black* while alive, turn *red* by being *boiled?*

70. Why does a *shrimp*, which is nearly *white* while alive, turn *red* by being *boiled?*

71. Why is the *shadow* of the *moon* stronger than the shadow of the sun?

72. Why does *hartshorn* take out the red spot in cloth, produced by *sulphuric* or any other *acid?*

73. Why will *powdered sulphur quench fire* more rapidly than water?

74. How does *starch* serve to *stiffen* linen?

75. Why should *lightning conductors* be *pointed?*

76. Why do *bricks* turn *green*, after they have been exposed to the weather?

77 When *potatoes* are *boiled*, why are those at the *top* of the boiler cooked *sooner* than those nearer to the fire?

78. If a silver *spoon*, which has been *tarnished* by an *egg*, be rubbed with a little *salt*, why will the tarnish disappear?

79. Why are *books* discoloured by age or damp?

80. Why does *sour milk curdle?*

81. Why does *churning* milk convert it into *butter?*

82. Why does the *sun* or fire *warp wood?*

83 Why does the *sun fade* artificial *colours?*

84. When a *knife* is sharpened on a *grindstone*, why is *oil* or *water* used?

85. Why does *bread* become *mouldy*, after it has been kept a few days?

86. Why does *meat putrefy* sooner in hot, damp weather, than in cold?

87. Birds, after they are killed, *keep longer* in their *feathers* than when they are plucked: Why is this?

88. Why do *plants*, which are kept in a window, *bend* to the *glass?*

89. Why does *Indian rubber* erase *pencil marks* from paper?

90. Why does *water rot wood?*

91. Why does *water* make a *hissing* noise when it is poured on *fire?*

92. Why will *hot* iron *bend* more easily than *cold?*

93. Why does *iron* turn first *red* and then *white* from *heat?*

94. Why does *hot* water *freeze* more quickly than *cold?*

95. Why does *water freeze* more quickly than *milk?*

96. Why are *glue*, *gum*, *starch*, and *paste* adhesive?

97. Why does a railway *train* make more *noise*, when it passes over a *bridge* or *meadow*, than when it runs over *solid ground?*

98. Why does *milk boil* more quickly than water?

99. Why will *milk burn* more readily than water?

100. Why is it impossible to *write* on *greasy paper?*

101. Why does rain "*bring down* the *cold?*"

102. Why does *turpentine* take out *grease* spots from cloth?

103. Why does *oxalic* acid take out *ink* spots?

104. Why does *waxing* cotton or thread make it *stronger?*

105. Why is a *stick* made *flexible* by *boiling* it?

106. Why does *manure* make land *fertile?*

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GLOSSARY.

Acetic Acid	called	Distilled Vinegar*	*Sulph. of Zinc*	called	White Vitriol
Citric „	„	Juice of Lemons†	*Nitrate of Potash*	„	Saltpetre
Nitrous „	„	Aqua Fortis	„ *Silver*	„	Lunar Caustic
Oxalic „	„	Salt of Lemons‡	*Prussiate of Potash*	„	Prussian Blue
Sulphuric „	„	Oil of Vitriol	*Tartrate of Potash*	„	Rochelle Salt
Sulph. of Alumina	„	Alum	*Acetate of Copper*	„	Verdigris
„ *Lime*	„	Plaster of Paris	*Muriate of Soda*	„	Table Salt.
„ *Iron*	„	Green Copperas	*[illegible] of Lead*	„	Goulard
„ *Copper*	„	Blue Vitriol	*Carb. of Ammonia*	„	Smelling Salts
„ *Magnesia*	„	Epsom Salts	„ *Lime*	„	Chalk Marble, &c
„ *Soda*	„	Glauber Salts	*Sup. acet. of Lead*	„	Sugar of Lead.

SUBLIMATES are chemical preparations, the basis of which is generally quicksilver. In CORROSIVE SUBLIMATES, the quicksilver is *extinguished*, either by vitriol, potter's clay, or some other ingredient. Benzoic acid is a sublimate without quicksilver.

SUBLIMATION is a similar process to distillation; only *solids* (such as metals are employed, instead of *liquids*.

N.B. — It may be profitable to remind the pupil that when the termination "ous" is used, it implies that the substance has less oxygen than when the termination "ic" is added—thus sulphurous acid contains less oxygen than sulphuric acid, &c.

* Distilled vinegar is an impure or diluted acetic acid.

† Citric acid is a rather crystalline substance, prepared from the juice of lemons.

‡ Salt of lemons is really a bin-oxalate of potassa, a compound of two equivalents of oxalic acid and one of potassa.

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